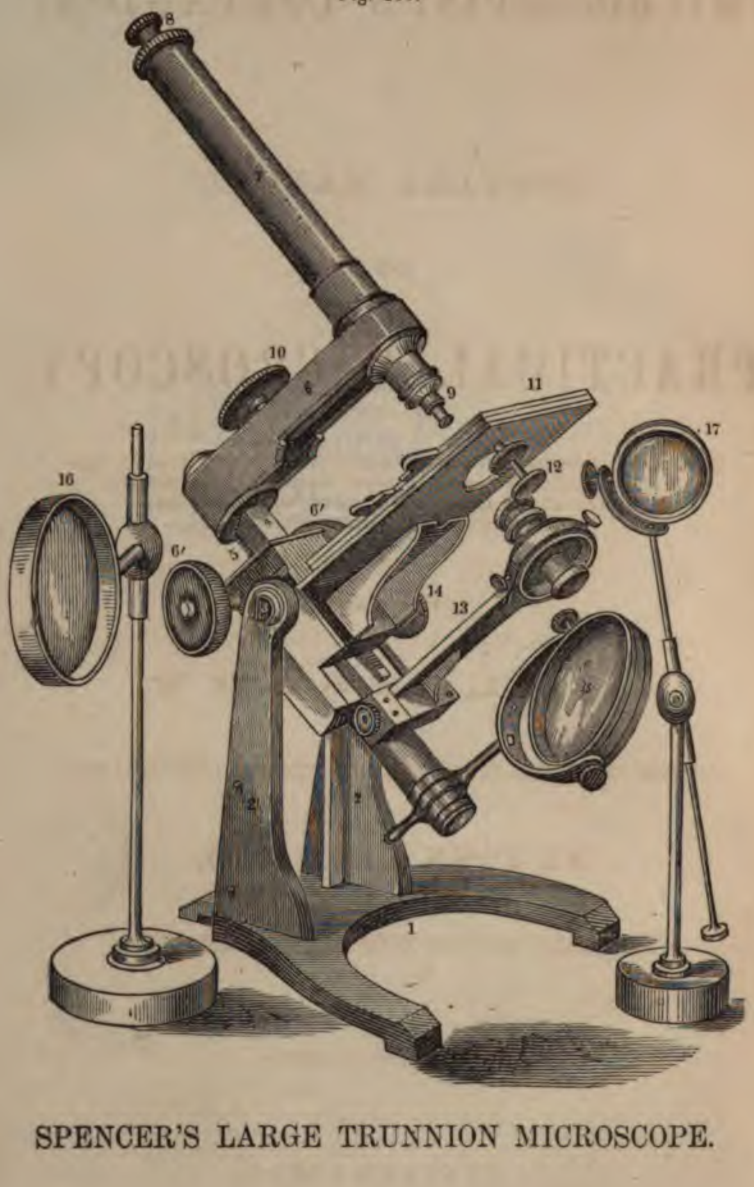
King

Fig. 110.



SPENCER'S LARGE TRUNNION MICROSCOPE.

THE

MICROSCOPIST'S COMPANION;

A

POPULAR MANUAL

OF

PRACTICAL MICROSCOPY,

DESIGNED FOR THOSE ENGAGED IN MICROSCOPIC INVESTIGATION, SCHOOLS, SEMINARIES, COLLEGES, ETC., AND COMPRISING SELECTIONS FROM THE BEST WRITERS ON THE MICROSCOPE, RELATIVE TO ITS USE, MODE OF MANAGEMENT, PRESERVATION OF OBJECTS, ETC.,

TO WHICH IS ADDED

A GLOSSARY

OF THE PRINCIPAL TERMS USED IN MICROSCOPIC SCIENCE.

BY JOHN KING, M. D.

ILLUSTRATED WITH ONE HUNDRED AND FOURTEEN CUTS.

CINCINNATI:
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1859.

P. C. BROWNE,
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43 EAST THIRD STREET.

TO

THOSE PERSONS

THROUGHOUT THE UNITED STATES,

WHO ARE ENGAGED

IN

MICROSCOPIC INVESTIGATIONS,

THIS WORK IS

RESPECTFULLY DEDICATED

BY

THE AUTHOR.

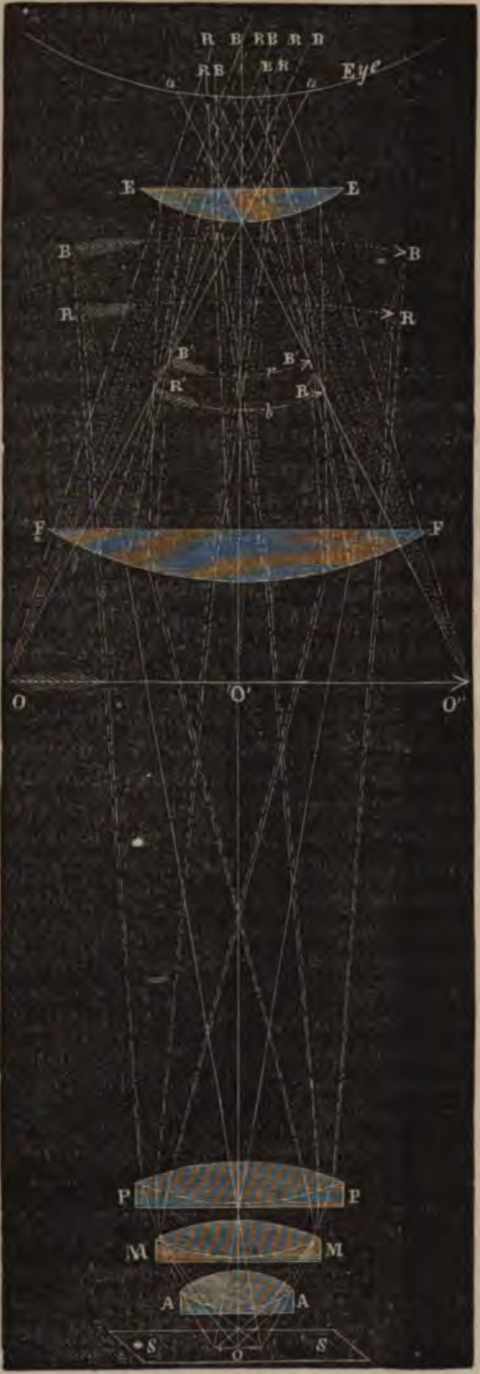


Fig. 111.

INTRODUCTION.

THE subject of microscopic investigation is one of a most fascinating and useful character, not only to the student, the zoologist, the mineralogist, the botanist, the physiologist, the geologist, the chemist, and the physician, but to every individual who would enrich his mind with the wonders and magnificence of the otherwise invisible world, or would protect himself from the impositions practiced in adulterating or variously deteriorating the necessaries as well as the luxuries of life. At this day, instead of being considered a mere toy in the hands of the curious, the microscope is the inseparable companion of literary and scientific men, whose studies it materially aids, exhibiting most interesting objects, opening a new and endless field of enquiry, and revealing many facts in nature, which, previous to its introduction were secrets absolutely beyond conception.

Heretofore, a great impediment to the progress of microscopic studies has been the costliness of the instrument itself, as well as of the various works which have been published relative to its use, and its valuable discoveries. At present, this difficulty no longer exists, and at an expense of forty or fifty dollars the man of limited means can now procure an instrument, called the "student's microscope," which will enable him to prosecute his investigations in nearly every department of nature. And to aid those who are prosecuting their enquiries in this highly instructive and entertaining field of observation, this work has been especially prepared. It will also be very useful to those who cannot procure the more costly English works, from which considerable of the practical matter in the present volume is compiled. The author has endeavored to place before the reader in as brief and explicit a manner as the subject will admit, divested of all superfluous or irrelevant matter, those various points in microscopic manipulations which are actually necessary for him to become practically acquainted with, particularly if he be a novice. Thus, this volume contains a list of the principal

works on the subject of microscopy, the names of the best American microscope manufacturers, together with the prices of their several instruments, the accessories which may become necessary during certain investigations, the mode of using the microscope determining the amount of its magnifying power, as well as the size of the objects examined, an account of test objects, the several methods of collecting, examining and preserving animalcules and other objects, the mode of preparing cells, pursuing micro-chemical investigations, etc., together with a glossary containing much important and necessary information, as well as an explanation of the principal technical terms and signs used by microscopists; thus rendering the work a very cheap, but useful and correct "multum in parvo."

The author was induced to prepare the present work not only for the purpose of replying to the numerous enquiries relative to the use of the instrument, etc., which have, from time to time, been received by him from those commencing microscopic studies, but also from the hope that a work of the kind might find favor with the students of schools, seminaries, colleges, etc., with the scientist, and with the great mass of community, and thus become a means of introducing the microscope into families, increasing the happiness around the domestic hearth, by contributing amusement with instruction, cultivating a taste for the beautiful, a love for the works of nature, and thereby enlarging and extending the sphere of the mental and intellectual faculties. And he will feel fully repaid for his labor, should such a hope be realized. He claims no originality in the matter contained in the work, which consists principally of *selections* from the *best writers* arranged to suit the plan he had in view of a brief, comprehensive, practically useful, and cheap publication. The authors to whom he is chiefly indebted are Griffith and Henfrey, (Micrographic Dictionary), Quekett, Pritchard on Infusoria, Hogg, Bennet, Beale, Schaht, and others, beside the London Quarterly Journal of Microscopical Science.

As the microscopist advances in his investigations, he may meet with difficulties, or require information which could not be expected to come within the limits of a work as elementary as the present; he will then require the assistance of authors who have entered into a more extensive and minute detail of all that belongs to the microscope. Thus, *on the general use of the Microscope*, the following works will be found useful, viz., *Brocklesby's views of the Microscopic World $1,—* Quekett on the Microscope $5,—*Hogg on the Microscope, $2,00, Microscopic Dictionary $12,—*Carpenter on the Microscope, $4,—London Quarterly Journal of Microscopic Science,

$5 per year,—Wythe on the Microscope, $1.25. *On its uses, etc., with insects and animalcules.* * Hassall's Microscopic Examination of Water, $0.75,—Siebold's Comparative Anatomy $3—Pritchard on Animalcules $12,—Johnston on Zoophytes $10.50,—Bell on Crustacea, $6.50,—Mantell's Invisible World $3.00,—Dana on Zoophytes $45,—*Drops of Water, by Catlow, $2.25, etc. *On Microscopic Botany.* *Schahton the Microscope, $1.75,—*Unger's Botanical Letters $1.25,—Quekett's Histology, $5.75,—*Coultas on Cryptogamia $.90, Robin on Parasitic Vegetables, $4. Schwann and Schleiden's Researches $3.25.—* The Plant, by Coultas, $1,—Hoffmeister's Higher Cryptogamia $5.75,—Mohl on the Vegetable Cell, $2. *On Diatoms and Desmidiaceæ.* Ralf's British Desmidiæ, (scarce) $18—Smith's Synopsis of Diatomacæ, 2 vols., $15. *On anatomy and Physiology.* * Beale on the Microscope, $3.75,—Hassall's Microscopic Anatomy by Vanarsdale, $8.—Tulk and Henfry's Manipulations $2.-50, Robin and Verdeil's Chemical Anatomy $11,—Kolliker's Human Anatomy $3.50,—Jones and Sieverking's Pathological Anatomy $3.-50,—Bowman's Medical Chemistry $1.30,—Manuals of Blood and Urine $1.60,—Bird on Urinary Deposits $1.50,—Bennet's Clinical Lectures $1.50,—Rokistansky's Pathological Anatomy $5,—Goadby's Text Book of Vegetables and Animal Physiology, $2.00,—Lehman's Physiological Chemistry $6,—Peaslee's Human Histology, $3,—and also, *Pereira on Polarized Light $2.25, Huxley on the microscope, Gerber and Gulliver's Microscopic Anatomy, Owen's Odontography, Vogel's Pathological Anatomy, Paget on Tumors, Lebert's great work, etc., etc.

Those marked with an asterisk are best suited for persons not far advanced in microscopic examinations; and the English and French works can be promptly obtained through the importing house of H. Bailliere, No. 290 Broadway, New York city, who will forward them to any part of the Union, as may be directed; or through the house of Robert Clarke & Co.; or Rickey, Mallory & Co., Cincinnati, O.

* "The microscope opens to the observer a new and unexpected world, full of beauty, perfection, and magnificence; in a single drop of water it presents to the astonished vision, living creatures, of most beautiful and varied forms, entirely unlike all former conceptions of organic existence, and so extremely minute that it would require from twenty-five thousand to eighty millions to fill the narrow space of one square inch. And yet, as small as they are, the microscope reveals to us their existence, their spontaneous motion, and their external and internal structures; it also makes known the fact that

* From the author's "American Family Practice."

these minute living beings are extremely reproductive, and "constitute the chief proportion of living bodies upon the face of the earth." They are found not only in the fresh water of ponds, brooks, rivers, and lakes, but even in the salty waters of the great deep, in some strong acids, in terraqueous matter, and in vegetable and animal fluids; indeed, there is no part of the world, either upon its external surface, or internally, but in which these microscopic beings can be found, either in a living or fossil state. The mortar of the builder, the chalky cliffs of Albion, extensive tracts of country in various parts of the world, as well as chains of mountains, the coral foundation of the Polynesian Archipelagoes, of the reefs and islets of the Indian Ocean, as well as many other places, beside slate, flint, sandstone, limestone, rocks, &c., all contain, and are, in fact, chiefly composed of the remains of once living, invisible animalcules. "Of the myriads upon myriads of organized beings created to work out the grand designs of Providence, all calculation seems futile; as the results would be far beyond the grasp of human comprehension. And the remains of these minute animals have added much more to the mass of materials which comprise the exterior crust of the globe, than the bones of elephants, mammoths, hippopotami and whales."

But the microscope does not terminate its utility here; it is equally necessary and useful to the geologist, the botanist, the mineralogist, the chemist, and the physician. To the latter in particular, it has demonstrated the minute structure of parts of the human system, which were previously altogether a mystery, and has assisted in affording a more perfect comprehension of the organic functions. The structure of the various parts of the system has, within a few years past, been thoroughly and correctly made known by the aid of this mighty instrument, so that no man can, at the present day, hold the title of a "respectable physician," who is not conversant with its revelations. Nor has its value ceased with a knowledge of the healthy structure; it affords a certainty in the diagnosis or detection of diseases, several of which cannot be correctly determined without it.

It is no less useful to the non-professional man, and to the community in general, who, by its employment, may frequently learn certain unhealthy conditions of the system, without having immediate recourse to a physician. Thus, the character of urine, as known by its uric acid, its urates, phosphates, oxalate of lime, blood-corpuscles, &c., as seen under the microscope, may enable an individual to become aware of changes taking place in the system not consistent

with health, at a very early period, even before any appreciable symptoms have developed themselves, and thus afford him information which will lead him to adopt a proper course of treatment long before the attack becomes serious or of a permanent nature. Engravings of the most common appearances of the urinary deposits under the microscope, are given in the work to which the reader is referred.

The non-professional man may also ascertain that many diseases of the skin depend upon, or are accompanied with microscopic vegtable growth, of fungous or algous character, as ring-worm of the scalp, dow-worm, some aphthous ulcerations of the throat, mouth, &c., and that other diseases again, are accompanied with microscopic animals, as the itch, acarus folliculorum, &c. The globules of blood seen under the microscope, appear as numerous "pale, and red, rough, bi-concave discs, having a tendency to turn upon their edges, and to arrange themselves in rolls like rouleax of coins; a very few white corpuscles, irregular in form, granular in surface, and rather larger than the red globules, will also be readily distinguished." To discover whether any stain consists of blood, it must be moistened with some white of egg, then scraped off the material holding the stain, and examined under the microscope, if the stain consists of blood, blood-corpuscles, as above described, will be distinctly visible. In this manner, in supposed cases of murder, may we distinguish between blood stains, and red spots resembling blood.

Beside the above named applications of the microscope, there are others of still more importance to the community, as *the detection of adulterations in food and drugs.* A writer observes, "to such a pitch of refinement has the art of falsification of alimentary substances reached that the very articles used to adulterate are adulterated. And while one tradesman is picking the pockets of his customers, a still more cunning rogue is, unknown to himself, deep in his own!"

The manner in which food is adulterated is not only one of degree but of kind. The most simple of all sophistications, and that which is the most harmless, is the mixture of inferior qualities of the same substance. * * * Secondly, the mixture of cheaper articles of another kind; thirdly, the surreptitious introduction of materials which, taken in large quantities are prejudicial to health; and fourthly, the admixture of the most deadly poisons in order to improve the appearance of the article 'doctored.'

"The microscope alone is capable of detecting at one operation the nature and extent of the more harmless but general of these frauds." It distinguishes with unerring nicety an admixture of the

common Circuma arrow root with the finer Maranta; it detects genuine ground coffee, from its adulteration with peas, beans, oats, dried bones, oak, or mahogany, sawdust, chicory, &c.; determines the presence of mildew in flour; of turmeric and flour in mustard; of red lead in cayenne pepper; of water, chalk, calves brains, molasses, annato, flour, oxide of iron, &c., in milk, as well as the richness of milk; it exposes fraudulent mixtures of lard with butter; of Prussian blue, turmeric, chalk, and copperas in green tea; of gum, black lead, Dutch pink, and leaves of other plants in black tea; of roasted wheat, beans, carrots, parsnips, horsechesnuts, oxide of iron, baked horse's liver, &c., in chicory; and of wheat flour, hundreds of sugar insects, sand, and albumen of bullock's blood in sugar. Impurities in butter, bread, cheese, molasses, spices, vinegar, and other necessaries of life may at once be detected by this powerful instrument, so that as a saving to the pocket as well as to the health, it should form a part of the domestic apparatus of every family.

The most useful and fascinating study, is that belonging to microscopic observation, and it is much to be regretted that means have not been heretofore employed to introduce its charms and value into the homes of the people—to their firesides. A more valuable gift from father to son, from husband to wife, from friend to friend, than that of a microscope, cannot be made; for, unlike any other instrument, it can bestow upon its possessor, amusement, profit, instruction, health, and happiness. Its astonishing and magnificent revelations are of so bewitching a nature, that the parent, the son, or the man of common sense, who has once become fairly acquainted with them, would rather pass his unoccupied hours at home, in the circle of his family, displaying to its members the powers and excellencies of his microscope, thus cultivating in their minds a taste for scientific pursuits, than to waste those hours away from home in the turmoil and strife of political excitements, in the mind and soul-destroying region of a porter-house, or, in any of those many dens of dissipation, debauchery, and vice, which throw out the most alluring temptations, to catch the indolent, the unwary, the careless and the ignorant; to rob wives of the affections of their husbands, to make sons rebel against and cause anguish to their parents, despoil wives and daughters of all self-respect, and render them among the vilest of the vile.

Unfortunately, some have conceived the microscope to be a mysterious instrument, capable of being managed or understood only by certain particular persons. This, however, is a great error; it is intended as an improvement upon our sense of sight. Objects which

can be seen well by the natural eye, do not require its assistance; but with those which are too small to be thus seen, we aid the power of vision by employing the microscope, and which every individual possessed of sight can readily use. Persons with imperfect sight use spectacles to improve this sense; and the microscope improves the magnifying and defining powers of the eyes.

A great obstacle to the more common use of the compound achromatic microscope, heretofore, has been in its expensiveness, but instruments are now made by our best opticians, called "student's microscopes," which will accomplish all that any person need desire. The value of a microscope does not lie so much in the beauty or workmanship of its brass mountings and other metallic accompaniments, as in the quality of its object-glasses and eye-glasses. An object-glass itself, however great may be its magnifying power, is useless unless it possesses penetrating and defining powers also. It is from a want of these latter powers in their objectives, that the French microscopes imported into this country are inferior in quality, notwithstanding the excellence of their brass-work and their low prices.

In purchasing a microscope, the name of its manufacturer ought always to be learned, from the fact that our best microscope makers never permit poor glasses to leave their workshops."

CHAPTER I.

PHENOMENA OF LIGHT. SPHERICAL AND CHROMATIC ABERRATION. SIMPLE MICROSCOPES.

In a work as limited as the present, it will be impossible to enter into a minute detail of the optical phenomena connected with the construction of microscopes; this will be found in the various works on the science of optics, especially in Brewster's Treatise on optic's, and Lardner's optics, as well as in brief, among writers on the Microscope, as Quekett, Hogg, Ross, Carpenter, Pritchard, etc., a reference, however, to some of these phenomena and to simple lenses may be necessary before commencing our remarks on the achromatic microscope.

Light is the principle which enables the brain to perceive objects, through the intermedium of the eye. What light is, has not been definitely settled; some philosophers have imagined it to be a delicate material substance propelled from luminous bodies in right lines, which substance striking against the eye, develops "vision," or the ability of feeling the form, color, height, breadth, etc., of any object, by means of the eye. Others have, and with more truthfulness according to my own view, considered light to be the result of the action of the electrical rays of one body upon those of another; as, for instance, the galvanic or electrical rays of the sun acting upon the electrical atmosphere of our earth, give rise to both light and heat. When one surface of the earth is not directly exposed to the solar electrical rays, darkness remains until it is acted upon by these rays. The prevailing hypothesis relative to light is, however, that space is occupied by a peculiar delicate, resilient substance, called *ether*, the atoms of which by their vibrations cause light. As the vibrations must necessarily cease or intermit during that portion of each twenty-four hours called night—if this hypothesis be true, it would seem that the immediate presence of a luminous body is necessary to produce the vibrations, or in other words, luminosity is required to cause light.

A simple line of light, the smallest that can possibly be ceived of, is termed *a ray;* a few of these rays issui

point, and being either parallel or diverging, are called when together, a *pencil* of light; a still greater number of rays collected together, constitute a *beam* of light.

When the rays of light strike against a body, the light is termed *incident;* the point of the body upon which the light strikes, is the *point of incidence;* a line drawn perpendicular to the surface from the point of incidence, is the *normal* to the surface at that point; and the angle formed by the incident ray and its normal, is the *angle of incidence.* When the incident rays of light are thrown back, they are said to be *reflected;* and this reflexion may be *regular*, as from a smooth, polished surface, or, *irregular*, as from an unequal surface in which the rays are reflected in various directions; it is this latter kind of reflection which renders bodies distinguishable by the eye. A reflected ray of light is on that side of the normal to the surface exactly opposite to the incident ray, and forms with the normal an angle equal to that existing between the incident ray and the normal, which is called the *angle of reflection;* or, in other words, the angle of incidence, and the angle of reflection are equal.

When the rays of light cannot pass through a body, it is called *opaque;* if the rays can pass through, the body is termed *transparent.* The degree of transparency varies with different bodies, being more or less perfectly transparent according to their density and thickness; when the rays are very imperfectly transmitted, the body is termed *translucent.*

The incident rays of light in passing through a transparent body, are always turned more or less out of their true or original direction, except when they fall perpendicularly, they are then said to be *refracted;* this refraction varies according to the density of the body, thus, carry the normal or perpendicular line through the transparent body,—then, if the density of the body through which the ray of light passes is *greater* than that of the medium out of which the light has just passed, the refraction will be *toward* the perpendicular line. But should the density of the transparent body be *less*, then the refraction will be *from* the perpendicular; in both instances, being always in the same plane. *The angle of refraction* is that produced between the perpendicular line and the refracted ray of light, and its degree (or sine) depends upon the density and transparency of the object through which it passes. The refracted rays of light like those of the

reflected, are on that side of the normal or perpendicular line opposite to the incident rays.

When a ray of white solar light is made to pass through a refracting medium, as for instance a glass prism, it will be found to have undergone a change, or to be decomposed; instead of being perfectly white, it is more or less colored. From this fact, ordinary solar light is supposed to consist of seven colored lights, which may be separated by a prism, in the following order, violet, indigo, blue, green, yellow, orange, and red. This separation of the colored lights is termed *dispersion*, or *chromatic dispersion of light*. The various colors above named, constitute the *prismatic* or *solar spectrum*, and they are due to the different refrangibility of the several colored rays which compose white solar light, the violet are the most easily refracted, the red the least, the other colored rays being refracted, between these two, according to their appearance in the solar spectrum.

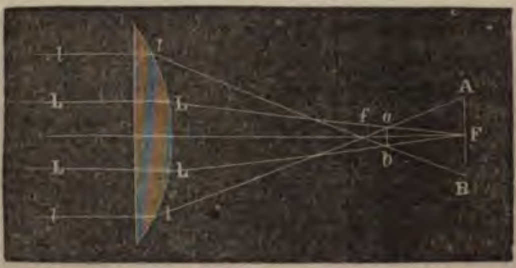
For the purpose of aiding the eye in discerning very minute or distant objects, as well as to overcome defects in the eye itself, certain transparent instruments are made, usually of glass, which are called *lenses*. Of these there are several, which are named according to their different forms, as follows—1. *double convex*, both surfaces being equally or unequally convex; 2. *plano-convex*, one surface being plane, the other convex; 3. *meniscus*, in which one surface is concave, the other convex, but so arranged, that the two surfaces would meet were they continued; the convexity of the lens is therefore greater than its concavity. As these three forms of lenses converge parallel incident rays, they are called *convergent lenses*. 4. A *concavo-convex* lens, is where one surface is concave and the other convex, but in which the two surfaces would not meet if continued; 5. *double concave*, where both surfaces are equally or unequally concave; 6. *plano-concave*, in which one surface is plane, the other concave. As these last three forms diverge parallel incident rays of light, they are called *divergent lenses*.

Fig. 1.

The *focus* is the point from which rays of light converge or diverge; the *principal focus* is the point to which parallel rays converge after reflection or refraction. Thus, in fig. 1, the parallel rays of light L L L L in passing through the plano-convex lens E E, are refracted and converge to a point at F, which is the principal focus of the lens. If, however, the rays of light diverge from a point posterior to the lens, as at F′, which is situated at a greater distance from the lens than F the principal focus, then these divergent rays will be refracted to a point beyond the principal focus, as at f, which is a focus. The nearer F′ is brought to the lens, the more distant from it, will be the focus f; the farther off F′ is removed, the nearer to the lens will be f. The point F′ is the point of divergence or the *radiant point*, and from the above interchange between the radiant point and the focus f, as determined by the distance of F′ from the lens, these two have been called the *conjugate foci*, because which ever of them be the radiant point the other will be the focus.

The above will be true in case the lens be perfect, and all the rays of each pencil of light be brought to an exact focus; but with ordinary lenses we find it to be different. Those rays which fall upon the lens near its periphery are more strongly refracted than those nearer its center, which gives rise to a deviation called *spherical aberration*. Thus in fig. 2, a pencil of light l L L l falls

Fig. 2.



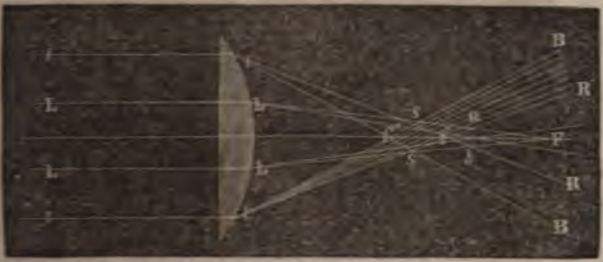
upon a plano-convex lens; the rays l l near the periphery of the lens are refracted to the focus f, while the central rays L L are refracted to the focus F. This aberration will render images very indistinct unless they be formed by the central rays only, or, by the peripheral rays only, and which may be accomplished by either covering the peripheral parts of the lens, or its center. The distance between F and f, is called the *longitudinal spherical aberration*, and that between *a* and *b* is termed the *lateral spherical*

aberration of the lens. The amount of spherical aberration will vary according to the shape of the lens, and the way in which it is exposed to the rays of light. In a plano-convex lens with its plane side exposed to parallel rays, as in fig. 2, the spherical aberration will be $4\frac{1}{2}$ times the thickness of the lens at its center; while, if its convex side be exposed to the parallel rays, the aberration will be only $1\frac{17}{100}$ths of the thickness of the lens. There will, however, be a slight variation from these proportions owing to the refractive power of the substance composing the lens.

In a double convex lens with equal convexities, the aberration is $1\frac{67}{100}$ths of its thickness. The least spherical aberration is found in double convex lenses whose radii of curvature are as 1 to 6; when the surface whose radius is 1, is turned toward parallel rays, the aberration is only $1\frac{7}{100}$ths of its thickness; but when the surface whose radius is 6 is exposed to parallel rays the aberration is $3\frac{45}{100}$ths of its thickness.

Descartes has shown that spherical aberration may be completely removed by the construction of lenses, whose sections are ellipses or hyperbola; but it has been found a very difficult matter to manufacture them, consequently, the microscope makers combine two or more lenses in such a manner that their opposite aberrations correct each other, while at the same time there is an increase of the magnifying power.

Fig 3.



Another serious cause of confusion arising from the use of ordinary lenses, is the unequal refrangibility of the differently-colored rays forming white solar light,—and which is termed *chromatic aberration*. In consequence of this aberration, in which all the rays are not brought to the same focus, the margins of the images of objects will be seen fringed with color. This chromatic aberration may exist in a lens whose spherical aberra-

tion has been corrected. Fig. 3, will aid us in explaining the cause of this. Parallel rays of light *l* L L *l* are thrown upon the flat surface of a plano-convex lens; the rays *l l* being near the periphery of the lens, are more strongly refracted than those which are near its center L L. Consequently, the colored rays of *l l* separate forming the spectrum, as seen at *l* B and *l* R. f is the focus of the red rays *l* R, and f' is the focus of the violet rays *l* B, the latter being at a less distance from the lens than the former. While the central rays falling perpendicularly or nearly so upon the convex surface of the lens, are hardly, if at all refracted; hence, an image will be seen nearly, if not quite clear in its center, while its edges will be colored. F f is the longitudinal spherical aberration, and F f' is the chromatic aberration, and the circle whose diameter is *s s* passing through the focus of mean refrangible rays at a point on the line f f' and directly between *s s*, is the circle of least aberration, or the mean focus.

Various methods have been adopted to diminish chromatic aberration; one is to lessen the diameter of the lens, but this at the same time diminishes the light. Another method is by combining several lenses of but slight curvature, as in many of the French instruments, but this does not perfectly accomplish the object. The best mode, as at present pursued, is to construct achromatic lenses of materials whose dispersive powers bears no relation to their simple refracting power, as for instance, flint, and crown glass; these vary in form, and are so disposed in an object glass as to form an *achromatic microscope.* This will be referred to again in speaking of the Compound Microscope.

Microscopes are simple or compound. The simplest form of a simple microscope is a convergent lens, usually double convex, or plano-convex, whose focal length varies from a quarter of an inch to two inches. The lens is secured in a frame of brass, or bone, and is made to shut within two plates of similar material, which not only serve to protect it from dust and injury, but answer the purpose of a handle. These microscopes, more commonly termed magnifying glasses, may be met with in the shops of opticians, either single, double, or triple, as seen in figs. 4, 5, and 6. The triple glasses are the best for ordinary use, as one, two, or three powers may be brought to bear upon an object under examination as desired, they take up very little more room in the pocket than a single lens, and are by no means expensive. Those

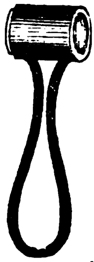
Fig. 4.

doublets or triplets which contain a thin plate of brass between each pair of lenses, with an orifice in its center opposite to the axis of the lens, for the purpose of cutting off the marginal rays of light, are superior to those in which the plates are wanting, inasmuch, as they not only have their magnifying power increased thereby, but the object is rendered more distinct.

These magnifying glasses are useful for a variety of purposes, and could not conveniently be dispensed with by persons engaged in any department of natural history. In the examination of many botanical and mineralogical specimens, insects, larger animalcules in water, some diseases of the skin, powders, etc. etc., they will be found invaluable; and in many instances where it is required to subject objects to an examination under the compound microscope, a preliminary employment of these will save much time and trouble, and aid us in bringing the object immediately under the objective glass, even when the simple lens can give us no further information than that the object to be considered looks like a mere speck on the glass-slide. In some cases, the handle of the lens is attached to an upright rod, on which it may be made to move up and down; this facilitates many examinations, especially the selection of the coarser diatoms from the finer, foraminiferous shells from sand, etc.

The Coddington lens, another form of simple microscope, when properly constructed, consists of a glass sphere, around the center of which a triangular groove is cut, and then filled with some opaque matter. This lens is very useful as a hand-magnifier, as it possesses a good magnifying power, with a large field of view, slight aberration, and is of a size very convenient for the vest pocket. A lens of similar construction is termed the Stanhope lens,

Fig. 5.



see fig. 5; it is a thick double convex lens one surface being of greater convexity than the other, and is useful for viewing some of the coarser urinary deposits, eels in flour paste, and in vinegar, scales from the wings of butterflies, and many other objects. These are to be placed upon the least convex surface of the lens, while the eye is applied to the most convex surface. When the least convex surface is applied to the eye, the lens forms a simple microscope having a focus of one fourth or one eighth of an inch. Although considerably used by some persons, it is deemed inferior to the Coddington lens, and is viewed more as a toy than a philosophical instrument.

Fig. 6.

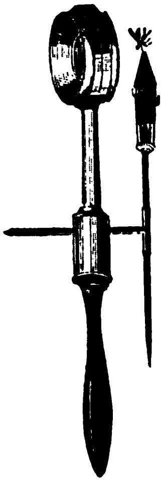
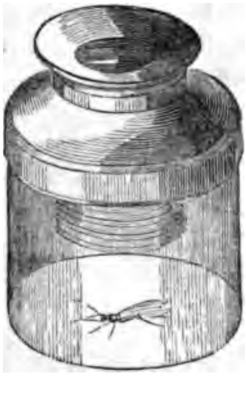


Fig. 6, represents a hand microscope mounted in a brass frame, with a stem, and a small pair of forceps attached, in which flowers, insects, etc., may be held while viewing them. The forceps is moved to the proper focus, so that the object can be seen distinctly, while the eye is placed close to the lens. These are useful instruments, and are generally packed in a small box with one or two lenses, for $1.25, or $1.50. Another form for large insects is seen in fig. 7; this may be used for viewing any large objects. The chief difficulty with it is the want of magnifying power which is not equal to the triple hand magnifier, represented by fig. 4. The focus in this instrument is obtained by means of the screw attached to the tube carrying the lenses.

Fig. 7.



There are several other varieties of simple microscopes, each being mounted for their intended purposes, as, Raspail's microscope for botanical dissections, selection of coarser from finer microscopic specimens, etc.; it is usually provided with four lenses whose magnifying powers vary from 50 to 300 diameters. It is unnecessary to name all the varieties of simple microscopes which have at various times been presented to the public. Perhaps the best one for general use is that described in Carpenter's work on the Microscope as *Gairdner's Simple*

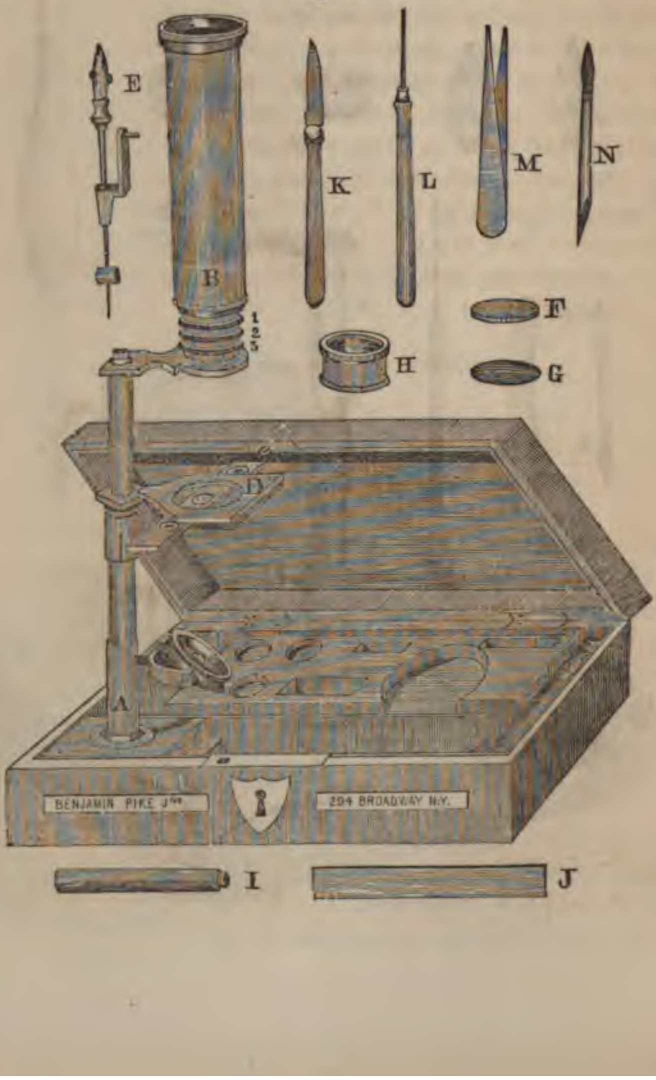
Microscope, and which, it is to be regretted, is not manufactured by our own opticians. It consists of a double stem united near one end, and which end forms the handle; the separated extremities of this stem carry, each, a brass ring, in one of which is a thin circle of glass on the back of which the object is to be placed, the other carries the lens; a milled-headed screw passes through that arm of the stem carrying the lens, by means of which the two arms may be separated or brought together, so as to bring the object into focus. The lenses, which are Wollaston doublets, should be three, giving magnifying powers of 50, 100, and 200 diameters. It may be employed in the examination of urinary deposits, botanical specimens, insects, animalcules, diatoms, etc.,

Fig. 8.

and may be conveniently carried in a small case in the vest pocket.

A very cheap and excellent pocket microscope, with three lenses, giving the power of 36, 64, 100, 169, 256, 400, and 676, times superficial measure, or, 6, 8. 10, 13, 16, 20, and 26, diameters, linear measure, and well adapted for large insects, seeds, sand from sponge, etc., may be obtained for about $5. It contains a stage to place objects on, and which slides on a rod to adjust the focus; a mirror moveable in any direction, for reflecting light through the object on the stage, if it be transparent; forceps, needle in a handle, insect box, ivory plate for opaque objects, con-

Fig 9.



cave and flat glasses, etc., the whole being packed in a neat box. Fig. 8, represents the instrument ready for use, with some of its accessories.

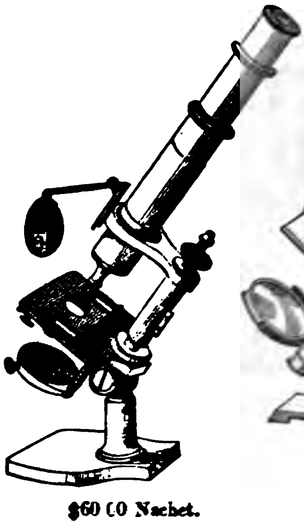
Fig. 9, represents a very useful single microscope for botanists, mineralogists, naturalists, etc., which may be had for about $10. It contains three or four powers, a stage for holding the objects, mirror, forceps, animalcule cage, glass slides, dissecting instruments, ivory plate for opaque objects, with case for containing the whole.

Fig. 10.

Fig. 10, represents a doublet or double lens hand microscope; it is composed of two plano-convex lenses, having the plane surfaces externally, mounted in brass, german silver, or ivory. They are a very useful lens for many purposes, as investigation of parts of flowers, insects, etc., and may be had for from 75 cts, to $1.00.

For purposes of dissection, Messrs. Spencer and Eaton, of Canastota, N. Y., and Messrs J. & W. Grunow of New Haven, Conn., manufacture superior microscopes, with all the necessary apparatus and movements.

ACHROMATIC MICROSCOPES.



$60 00 Nachet.

$27.00 Student's.

CHAPTER II.

THE COMPOUND MICROSCOPE—ITS AMERICAN MANUFACTURERS, AND PRICES.

A COMPOUND microscope is an instrument adapted for delicate observations, and is so called because the magnified image of the object produced by the *object-glass*,* and which is brought to a focus near the field-lens of the eye-piece, is again magnified by the *eye-glass* before it enters the eye. To be, however, at all fit for use, the compound microscope must be rendered *achromatic*, by having both its spherical and chromatic aberrations properly corrected. In the best microscopes, the object-glass is composed of three lenses, and the eye-piece is what is called Huyghenean.

Fig. 11, is a section of a compound achromatic microscope. The object to be examined is represented by O, immediately above which is seen the object-glass, consisting of three achromatic lenses. The eye-piece is composed of two plano-convex lenses; E E being called the eyeglass, and F F the field-glass. At B B is a dark stop or diaphragm. The course of the light is shown by three rays, drawn from the center, and three from each end of the object O; these rays, if not prevented by the lens, F F, or the diaphragm at B B, would form an image at A A; but as they meet with the lens F F, in their passage, they are converged by it, and meet at B B, where the diaphragm is placed to intercept all the light except that required for the formation of a perfect image; the image at B B is further magnified by the lens E E, as if it were an original object. The triple achromatic combination forming the object-glass, and constructed on Mr. Lister's improved plan, although capable of transmitting large angular pencils, and corrected as to its own errors of spherical and chromatic aberration, would nevertheless, be incomplete without an eye-piece of peculiar construction, termed a Huyghenean eye-piece to be described hereafter.

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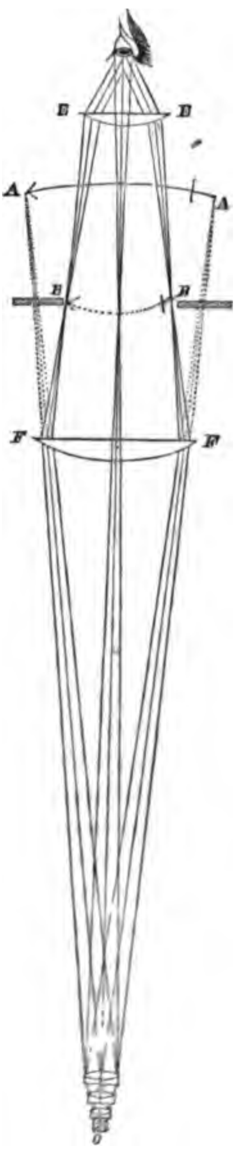
*Words in italic, throughout the work not otherwise explained, will be found in the glossary at the latter part.

Fig. 11.



In the cut on page, 6, fig. 111, is an enlarged section of the microscope. S S is a glass slide holding the object O; A A, M M, P P, are the three achromatic lenses forming the object glass, being the Anterior, Middle, and Posterior. As in fig. 11, the lines drawn from the center, and from each end of the object O, show the manner in which the direct and oblique rays of light proceed through the object-glass toward the eye-piece. The optical center of the object-glass taken as a whole, is at that point where all the axial rays of the several pencils of light cross each other.

The *Negative Eye-piece*, so called, "was invented by Huyghens for telescopes, with no other view than that of diminishing the spherical aberration by producing the refractions at two glasses instead of one, and of increasing the field of view. It consists of two plano-convex lenses, with their plane sides toward the eye, and placed at a distance apart equal to half the sum of their focal lengths, with a stop or diaphragm placed midway between these two lenses. Huyghens was not aware of the value of his eye-piece; it was reserved for Boscovich to point out that he had by this important arrangement, accidentally corrected a great part of the chromatic aberration. The Huyghenean eye-piece is represented in the cut on page 6, *fig.* 111, F F being the field-glass, E E the eye-glass, and on the line O O′ O′′ are the extreme rays of each of the three pencils of light, emanating from the center and ends of the object O, of which, but for the field-glass, a series of colored images would be formed from R R to B B; those near R R being red, those near B B blue, and the intermediate ones green, yellow, and so on, corresponding with the colors of the prismatic spectrum. This order of colors

is the reverse of that occurring in the common compound microscope, in which the object-glass composed of a single lens projects the red image beyond the blue.

"The effect just described, of projecting the blue image beyond the red, is purposely produced, for reasons presently to be given, and is called *over-correcting* the object-glass as to color. It is to be observed that the images B B, and R R, are curved in the wrong direction, to be distinctly seen by a convex eye-lens, and this is a further defect of the compound microscope of two lenses. But the field-glass, at the same time that it bends the rays and converges them to foci at B′ B′, and R R′, also reverses the curvature of the images as there shown, and gives them the form best adapted for distinct vision by the eye-glass, E E. The field glass has at the same time brought the red and blue images closer together, so that they are adapted to pass uncolored through the eye-glass. To render this important point more intelligible, let it be supposed that the object glass had not been over-corrected, that it had been perfectly achromatic; the rays would then have become colored as soon as they had passed the field-glass; the blue rays, to take the central pencil for example, would converge at *b*, and the red rays at *r*, which is just the reverse of what the eye-lens requires; for as its blue focus is also shorter than the red, it would demand rather that the blue image should be at *r*, and the red at *b*. This effect we have shown to be produced by the over-correction of the object-glass, which protrudes the blue foci, B B, as much beyond the red foci, R R, as the sum of the distances between the red and blue foci of the field-lens and eye-lens; so that the separation, B R, (between the field-glass and eye-glass) is exactly taken up in passing through those two lenses, and the whole of the colors coincide as to focal distance as soon as the rays have passed the eye-lens, as seen above the eye-glass, at B R, R B, etc. But while they coincide as to distance, they differ in another respect; the blue images are rendered smaller than the red by the superior refractive power of the field-glass upon the blue rays. In tracing the pencil of light after it has passed the field-glass, double dotted lines are seen passing toward B′ and R′, the right hand ones of each of which represent the blue rays, and the left hand ones the red. This is the accidental effect in the Huyghenean eye-piece pointed out by Boscovich. The separation into colors by the field-glass, is like the over-cor-

rection of the object-glass; it leads to a subsequent complete correction. For if the differently colored rays were kept together till they reached the eye-glass, they would then become colored, and present colored images to the eye; but, fortunately, and most beautifully, the separation effected by the field-glass causes the blue rays to fall so much nearer the center of the eye-glass, (where, owing to the spherical figure, the refractive power is less than at the margin,) that the spherical error of the eye-lens constitutes a nearly perfect balance to the chromatic dispersion of the field-lens, and the red and blue rays, above the eye-glass at R R R R, and B B B B, emerge sensibly parallel, presenting, in consequence, the perfect definition of a single point to the eye. The same reasoning is true of the intermediate colors, and of the other pencils."—*Ross.*

From this arrangement of the eye-piece the image of the object appears magnified at O O′O″ appearing on a flat field, and wholly free from spherical or chromatic aberration, and a field of view is obtained from *a a* at the eye piece, equal in diameter to O O″.

The object-glasses as represented at P P, M M, and A A, consist of three plano-convex lenses with the plane surface toward the object. In fact, each lens is compound, consisting of a double convex lens cemented to a plano-concave one, the two component lenses being made of glass of different densities. Its action is as follows:—the object O is placed within the principal focus of the anterior lens A A, so that a virtual image* is formed in front of the lens; the rays from this image fall on the second lens, but the image is so near, even to the second lens M M as to cause the formation of a second virtual image; the rays from this second virtual image fall upon the posterior lens P P, and are refracted by it so as to form an inverted magnified image behind the whole combination, which last image is further magnified by the eye-piece.

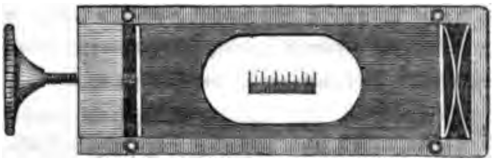
The best microscopes are usually furnished with three Huyghenean eye-pieces, and one *micrometer* eye-piece. The first are marked A, B, and C, or 1, 2, and 3. A is the longest eye-piece, and is of the lowest power; it is best adapted for view[illegible] the circulation in the frog's foot, mollusca, small [illegible]

*When the rays of light actually pass through the [illegible] *real*; when they do not thus pass, the image is *virtual*.

large ones, seeds, coal, thin sections of wood, fossil shells, the fructification of ferns and mosses, etc. The next eye-piece of middle power, is B, which is used for viewing minute dissections of insects, thin sections of bones, crystalline lens of eyes, pollen of flowers, details of large objects, animalcules in water, crystals by polarized light, urinary deposits, etc.; the highest power, is the shortest eye-piece C, though some microscope makers furnish a still more powerful one, marked D. The C eye-piece is used in the investigation of the intimate structure of delicate tissues, animalcules in water, diatoms, desmidiæ, volvox globata, raphides, scales from the wings of insects, test objects, etc. But in the use of these eye-pieces, much will depend upon the judgment of the investigator relative to the object under investigation. Should there be any imperfections in the objective, the more apparent will these become, when using the more powerful eye-piece.

The *micrometer eye-piece*, or positive eye-piece is the invention of Ramsden; it consists, the same as Huyghen's, of two plano-convex lenses, but with the convex surface of the field-glass toward the eye-glass, instead of its plane surface. In the ordinary Huyghenean eye-piece, the image is formed at the diaphragm which is placed between the eye and field-glass, but in the Ramsden eye-piece the image is formed outside of the field-glass; and at this point, which is the focal point of the eye-glass, a micrometer or glass divided into $\frac{1}{100}$ths, or $\frac{1}{500}$ths, etc., of an inch is placed. The defining power of a Ramden's eye-piece is not equal to that of a Huyghen's, unless it be made of two achromatic combinations, which is rarely the case; the former eye-piece gives the best view of the micrometer, which is all that is

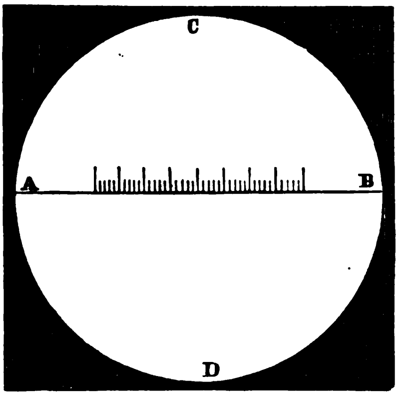
Fig. 12.



required in measuring; the latter gives the best and clearest view of the object, which is slightly colored when the Ramsden is used. The negative eye-piece is, however, frequently used as a micrometer, an opening being made in the sides of the tube of the eye-piece, so that a micrometer slide, *see fig.* 12, may be passed in across the field in the focus of the eye-glass.

Instead of the ruled glass micrometers, they are frequently made by stretching two threads of cobweb across the field, one of which may be moved by means of a micrometer screw, for the purpose of measuring; but these micrometers are very expensive, although they are the most accurate. Dr. White of New Haven, Conn., has invented a very simple and satisfactory micrometer, see fig. 13.

Fig. 13.



The field of view A B C D is occupied with a semicircular plate of thin glass A C B, which is fastened to the diaphragm of a Huyghen's eye-piece by means of some cement. Along the central part of the straight edge of this glass, A B, are ruled lines, varying as may be required, from $\frac{1}{100}$ths to $\frac{1}{1000}$ ths of an inch apart. As only one half of the field of view is obstructed by this ruled glass, and as the obstruction is but slight, this micrometer eye-piece, answers at once the purposes of ordinary investigation, and measurement, the latter of which may be effected by moving the slide containing the object, under the object-glass. By this means, saving the time and trouble required in changing the eye-pieces, when the size of an object is to be determined.

The most simple, accurate, and self-calculating micrometer, is *Fraunhofer's Stage-screw Micrometer;* this measures independent of the magnifying power employed, and gives the dimensions of any object at once, with great accuracy, and without any necessity for the microscopist to make calculations as with ordinary micrometers. Its price is $40, and can be had of the Messrs. Grunow, New Haven, Conn. White's micrometer slip of glass can likewise be had of them, for $2.

As an explanation of the various microscopes of different manufacturers, their accessories, prices, etc., are matters of considerable interest to those about engaging in micros-gations, a few pages will be occupied with these for the benefit of the reader.

There are various forms adapted to microscopes by the different manufacturers of these instruments, the preferable ones being those which are now generally adopted by the best microscope makers in England, and in the United States. The French instruments are generally inferior to those of the above named countries, the objectives being less perfect, the stage too small, and the microscope permanently vertical, as seen in fig. 14. They are, however, much cheaper than any other instruments, and some of them will be found to answer excellently well, especially those of Nachet, and Oberhausen; of the above kind, Oberhausen furnishes a Student's Microscope for $27 or $30, giving two achromatic powers of 175 and 300 diameters. An Oberhausen's instrument with five eye-pieces, three sets of object-glasses, prism to draw objects on paper, with magnifying powers varying from 40 to 800 diameters, may be had for $100 or $115. Nachet furnishes a vertical microscope, *see fig.* 15, with two eye pieces, two sets of object-glasses, illuminating lens, and fine adjustment, with magnifying powers varying from 60 to 500 diameters for $45 or $50. He also furnishes a microscope on joint to turn at any angle, *see fig.* 16, with the same apparatus as the preceeding, for $60 or $65.

Fig. 14.

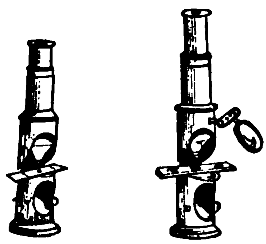
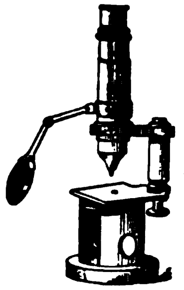


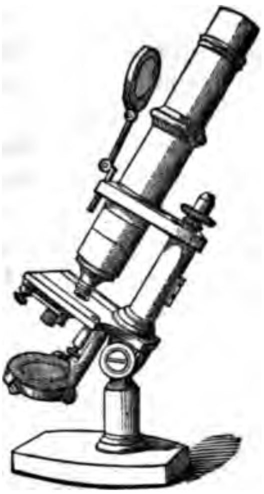
Fig. 15.



The instruments manufactured by Mr. A. Ross, Powell and Lealand, Smith and Beck, and others in England, are of superior construction, with the greatest accuracy in the combination of their lenses, and other necessary apparatus, and they, together with the French instruments may be obtained by those who desire them through any of the following houses, viz.: B. Pike, New York City; Joseph M. Wightman, Boston; H. Bailliere & Co., New York City; James W. Queen, Philadelphia; C. T. Amsler, Philadelphia; McAllister & Bro. Philadelphia; Jas. Foster, Cincinnati; Robert Clarke, & Co., Cincinnati; H. Ware, Cincinnati; etc., etc. Among some of the instruments which can more readily be obtained from the above

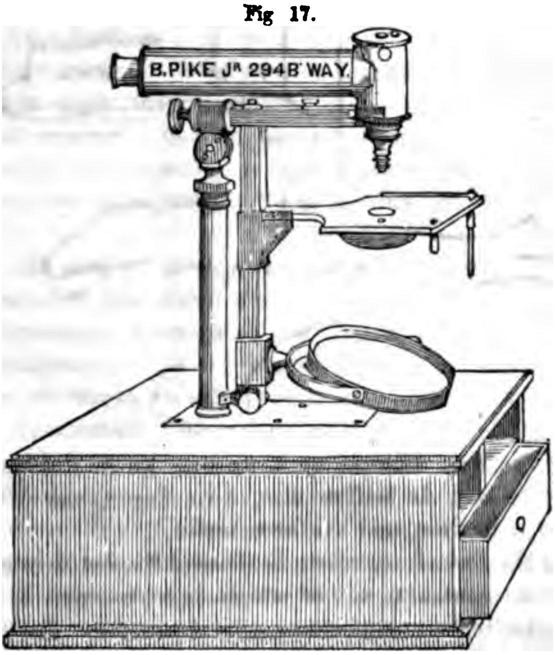
named gentlemen, one is represented in fig. 17. This is made after the Chevalier pattern, and is so arranged as to be used vertically, or, when examining fluids and animalcules, horizontally. It contains two eye-glasses, six object-glasses, giving different magnifying powers, illuminator, micrometer, camera lucida for drawing objects, dissecting instruments, etc., all packed in a mahogany case with three drawers, for $125 to $150.

Fig. 16



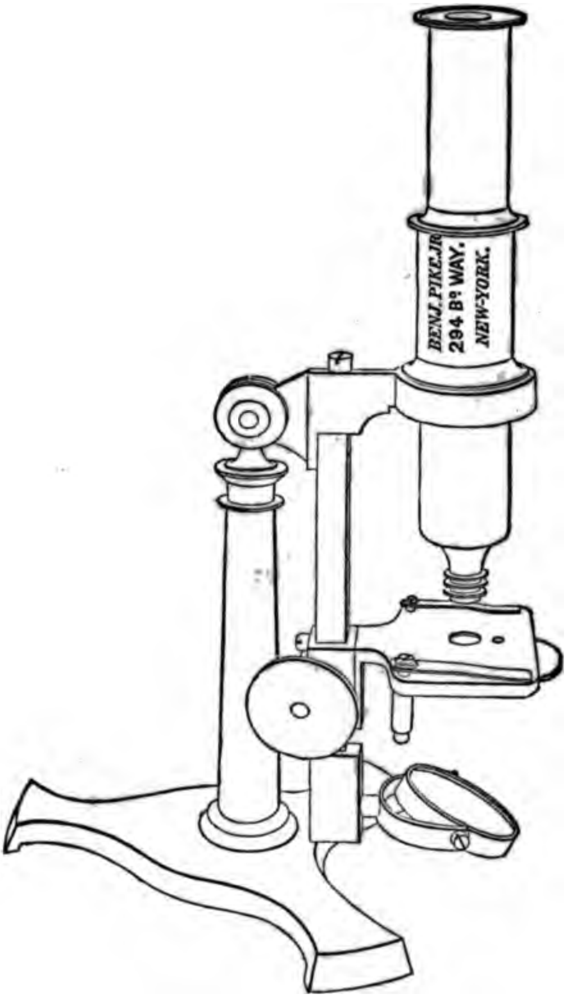
A compound achromatic microscope, the body of which may be turned at any angle, with three objectives and eye-glasses, and furnished with diaphragm, forceps, glass slides, test objects, dissecting knife, etc., may be had for $23. The general appearance of this microscope is seen at cut fig. 18.

Fig 17.



Another instrument by the same maker, as represented by fig. 19, with all the necessary accessories for investigation

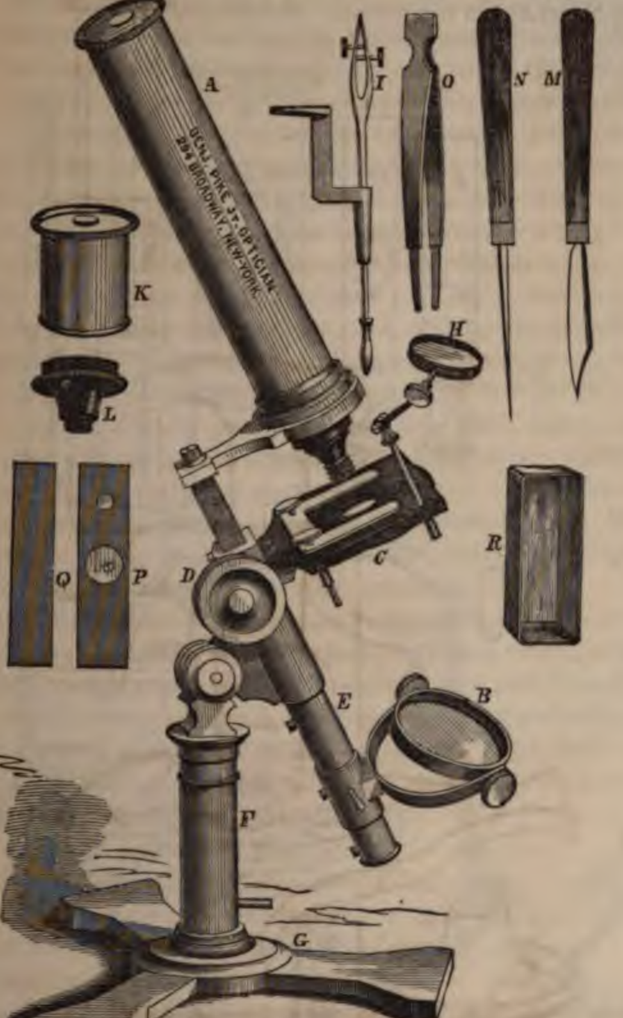
Fig. 18.



glasses, objectives, forceps, stage-forceps, knife, fluid-box, etc., etc., may be had for $40 to $60, according to the power and number of objectives, and the accessories.

Among the French microscopes those of Nachet have acquired considerable reputation, one of which is represented by fig. 20, though this optician manufactures several patterns. The one illustrated here, with all the various accessories, six objectives or nine as may be required, polarizing apparatus, etc., may be had for

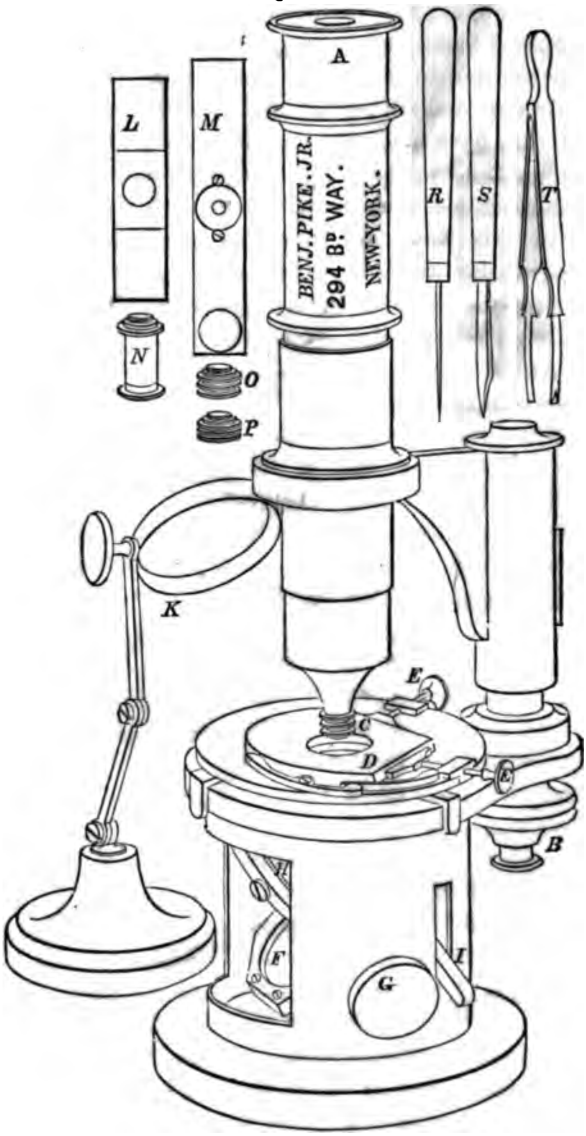
Fig. 19.



from $75 to $125. Nachet makes some of his instruments to turn at any angle, which is preferable to a permanently vertical one; some are made with a prism near the eye-piece, the tube into which the latter enters being bent at a suitable angle for the eye, without requiring to look downward; and again, some are

so made, that two, three, and even four persons can examine the same object at the same time. *See fig.* 20.

Fig. 20.

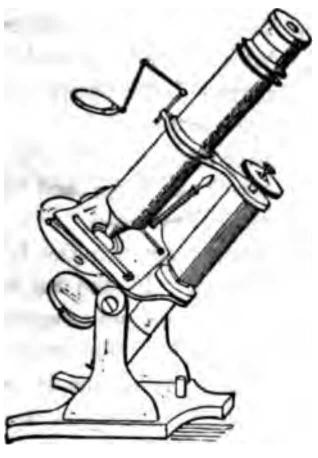


It is not intended however, to refer at all to foreign instruments or their makers, further than to name them, because, 1.,

those which are good are more costly than similar instruments by our own manufacturers, or, at least, are of equal price; 2., those which are cheap, are not worth having, and many of those who have purchased these poor instruments with the design of attending to microscopic investigations, have been very much disappointed in them, and supposing all microscopes to be of a similar character, they have neglected to pursue their investigations any further, some believing that a peculiar art was necessary to learn before examinations could be properly and satisfactorily conducted; in this way inferior microscopes accomplish a great deal of harm; 3., we have in our own country manufacturers who can supply us with instruments equal, if not superior, to the best of foreign construction, and, generally, at considerably less prices. And it may be proper to state here that, in the higher priced microscopes, there is a great deal of expensive workmanship about the stand, by no means necessary in the greater part of those investigations which may be pursued with them; although in some geological examinations, and observations of ultimate structure, they become quite essential.

A student's microscope, *see fig.* 21, is prepared by Mr. Jas. W. Queen of Philadelphia, for about $50, which is very portable, and will be found quite useful. It consists of a cast iron stand upon which the body of the microscope and its accessories are sustained; the microscope can be bent at any angle between a vertical and horizontal position, as will best suit the observer. The stage is movable by means of a lever, and has underneath it a diaphragm perforated with orifices of different sizes; a revolving plate is also attached to it, to which the polarizer is fastened whenever its use is required. The mirror slides on the tube carrying it, and may be turned at any angle to give direct or oblique light. A condensing lens, is attached to the instrument, for the purpose of throwing light upon opaque objects, when under examination. It has also a fine adjustment, two eye-pieces, two object-glasses, and

Fig. 21.



polarizing apparatus; and gives magnifying powers varying from 60 to 500 diameters. The whole is contained in a neat box of mahogany, with handle, lock, and key. When desired, a prism for drawing objects, as well as higher powers, will be furnished, by the manufacturer.

Spencer and Eaton, of Canastota, N. Y.; and J. & W. Grunow & Co., of New Haven, Conn., manufacture microscopes of superior excellence, fully equal, to say the least of them, to any of the English instruments. The Canastota gentlemen prepare object glasses of much greater *angle of aperture* than any other manufacturers in the world, and which for power of penetration and sharpness of definition are not excelled by any. Their angle of aperture for the $\frac{1}{12}$th inch object-glass is 178°, while the greatest angle given by other makers, does not exceed 170°; the ordinary angle of the majority of the best foreign objectives being about 130° or 140°.

Spencer's Trunnion Microscope, is represented in the Frontispiece, Fig. 110. 1. Is a strong tripod on which are mounted,

2, 2, two uprights strengthened by internal buttresses. At

3, the whole of the instrument turns, so as to enable it to take a horizontal or vertical position, or any intermediate inclination. This movable part is fixed to the axis near its center of gravity, and consists of

4, a triangular bar, which may be moved up or down for the coarse adjustment by 5, a rack and pinion, connected with 6′ the milled heads, one on each side of the instrument.

6, Is a strong movable arm attached to the triangular bar, 4, which may be turned away from over the stage, and which carries 7, the compound body, with its

8, eye-piece, and

9, object-glass; this arm also encloses the fine adjustment by screw and lever, and which is effected by

10, the milled head.

11, Is the stage 4 inches by 6; this may be plain or movable, as desired. In the cut it is movable in various directions by means of screws connected with 12, the two milled heads placed beneath it. The stage is supplied with a movable ledge, to hold the slides firmly, when the microscope is in an inclined position. By a simple contrivance, both the plain and movable stages may be removed from or attached to the instru-

ment, without at all interfering with their firmness or steadiness; so that when the microscopist possesses both, he can employ either at pleasure.

13, Is the accessory arm for carrying the diaphragm, polarizer, illuminating or condensing lens, etc., and which may be moved up and down by a rack and pinion, connected with

14, the milled head.

15, Are the mirrors, consisting of a concave mirror on one side, about four inches in diameter, and a plane mirror on the other about three inches in diameter; these mirrors can be moved in any direction required for either direct or oblique light, and the arm holding them slides upon the rod to which it is attached, so that the mirrors may be made to approach or recede from the stage, as may be desired.

16, Is the large bull's eye condenser on a stand, for throwing light upon opaque objects under examination.

17, Is the small condensing lens on a stand, for the same purpose, but to be used in connection with 16. Both of these lenses may be moved in any direction.

This instrument although not actually necessary in ordinary observations, is, however, a superior one, and will be found a great luxury to those with whom price is no object, as it is adapted to every kind of investigation.

Spencer and Eaton supply several kinds of microscopes varying from $45 to $350 or $400; their prices are as follows:—

1. First class large trunnion microscope *see fig.* 110 with double mirror, plain stage, movable stage, two extra arms for diaphragm, polarizer, etc., and coarse and fine adjustments, ...$125.00
2. Small Trunnion, as above, ... 75.00
3. Standard Microscope, ... 50.00
4. Student's microscope, with eye-piece, and ½ inch objective, angle of aperture 30°, ... 30.00
5. Eye-pieces, A, B and C, each, ... 5.00
6. Large condenser, for opaque objects, ... 8.00
7. Small do, ... 7.00
8. Diaphragm, ... 3.00
9. Camera Lucida, ... 5.00
10. Micrometer Eye-piece, ... 10.00
11. Polarizing Apparatus, ...$15, 20, and 25.00

12. Achromatic Condenser, ... $15 to 35.00
13. Animalcule Cage, ... $2 to 3.00
14. Compressor, ... 5.00

The prices of their objectives are ....

2 inch, first class,				....	$20.00
1 inch, do				....	23.00
$\frac{1}{2}$ inch, angle of aperture			70°,	....	30.00
$\frac{1}{2}$ inch,	do	do	30°,	....	12.00
$\frac{1}{4}$ inch,	do	do	125°,	....	40.00
$\frac{1}{4}$ inch,	do	do	93°,	....	35.00
$\frac{1}{4}$ inch,	do	do	75°,	....	30.00
$\frac{1}{4}$ inch,	do	do	50°,	....	15.00
$\frac{1}{8}$ inch,	do	do	170°,	....	50.00
$\frac{1}{8}$ inch,	do	do	130°,	....	45.00
$\frac{1}{12}$ inch,	do	do	178°,	....	100.00
$\frac{1}{12}$ inch,	do	do	150°,	....	75.00
$\frac{1}{16}$ inch,	do	do	178°,	....	125.00

Notwithstanding the apparent costliness of these instruments, Messrs. Spencer & Eaton can furnish an instrument for $45, with two objectives, an inch, and $\frac{1}{4}$ inch, and which is excellently well adapted to all medical and ordinary investigations, *see fig.* 22; for $75 and $100, an instrument can be procured which will be found sufficient for nearly all the purposes to which a microscope is applied.

This microscope, fig. 22, is so arranged that the owner of the instrument may from time to time add to it such other accessories, eye-pieces, and objectives, as he may require. The tripod and arm carrying the compound body is of cast iron, japanned; the compound body, and arm carrying the mirror is of brass, as well as the stage, and the clip for securing the slides. The instrument may be inclined at any angle, and the coarse and fine adjustments are made with a rack and pinion connected with a milled head, near the upper part of the iron arm, carrying the compound body up and down within a tube, but which milled head has been over-looked, in the cut, by the engraver. The mirror is about three inches, concave, and may be moved in any direction. One eye-glass, and two object-glasses, 1 inch, and $\frac{1}{4}$ inch, accompany the instrument, giving the magnifying powers of 60 and nearly 300 diameters.

The Messrs. J & W. Grunow & Co., manufacture a first

Fig. 22.

SPENCER'S STUDENT'S MICROSCOPE.

class microscope, which will bear comparison, with the best of foreign construction, and though their higher object-glasses, have not the great amount of angle of aperture given by Spencer & Eaton, yet they will be found of excellent penetration, and good definition, giving with the eye-glasses a large, clear, and flat field; and their lower powers, including the ¼th inch, for which they received a prize at the New York Exhibition, in 1853, are almost equal to those of the Canastota firm. Their form of stand, for steadiness, ease of management, simplicity, and economy, is unrivalled—and their movable stage with universal motion in one plane by a lever, improve[illegible]bly executed by them, is being now adopted in the [illegible]uments.

Fig. 23.

GRUNOW'S LARGE MICROSCOPE,

The prices of their instruments are as follows:—

1. Improved large microscope, *see fig.* 23, mounted on a stout brass tripod and uprights, with rack and pinion movements for coarse adjustment; screw and lever

for fine adjustment; stage four inches square, movable in every direction by a lever, and the under side of which is fitted for the attachment of polarizer, condenser, and other accessories; plane and concave mirrors, movable in every direction; two eye-pieces, A, and B,....................................$125.00.

Fig. 24.

2. A smaller one of the same cons $90.00
3. Best Students' microscope, se and firm tripod of cast-iron, ja age, coarse and fine adjustments, fitted

for the application of accessory apparatus, two eye-pieces, 1 inch and ¼ inch object-glasses, in a neat case, $70.00

Fig. 25.

4. Smaller Students' microscope, *see fig.* 25, mounted on a japanned cast iron tripod base and upright, with a trunnion joint to incline it at any angle, (the same as with the preceding instruments) coarse adjustment effected by sliding the compound body in a stout brass tube, fine adjustment by screw and lever, mirror movable in any direction, movable diaphragm, two eye-

pieces, 1 inch and ¼ inch object-glasses giving magnifying powers of about 30, 50, 200, and 350 diameters, and the stage so arranged that any accessory apparatus may be added and used as required, all in a neat case,... .... 60.00.

5. An Educational Microscope, well suited for schools, students, farmers, mechanics, merchants, private families, and for young gentlemen and ladies, and which is a very useful and decidedly cheap instrument. This is an excellent instrument, and capable of answering every purpose for which a microscope can be used by

Fig. 26.

the above-named class of [illegible] and will frequently be found of great [illegible] [illegible]ific microscopist when engaged in [illegible] [illegible] observation. *See fig.* 26. It is [illegible] [illegible]anned, cast-

iron tripod, is movable at any angle, the coarse adjustment is effected by sliding the compound body in a stout tube, the fine adjustment by a screw with milled head beneath the stage; the stage is two by three inches, with clips to hold the glass slides; a diaphragm plate is attached below it, with orifices of various sizes; and a concave mirror movable in every direction; two eye-glasses accompany this instrument, and two second class objectives, 1 inch and ¼ inch, giving magnifying powers of 40, 70, 180, and 350, diameters. The whole in a neat case, ... $45.00

6. The same, with polariscope, camera-lucida for drawing objects, stage-micrometer, bull's eye condenser for opaque objects, animalcule cage, stage-forceps, hand-forceps, and a set of dissecting instruments, ... $75.00

7. A portable microscope, *see fig.* 27, the same as fig. 24, as to its arrangement and apparatus, except that the microscope body and its various parts are mounted on three stout brass legs, which are made to fold together, and the whole is packed in a small case, $105.00

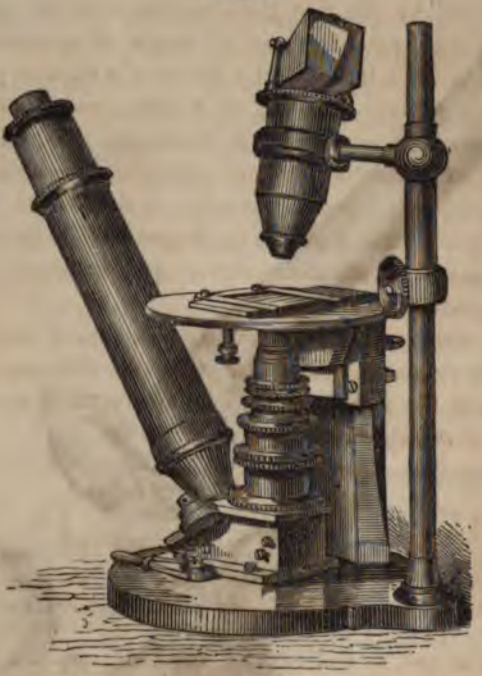
8. These gentlemen also manufacture a chemical or Inverted Microscope, for chemical, geological, medical, botanical, and indeed all purposes for which the ordinary instrument is used. It is mounted on a revolving foot, with coarse and fine adjustments, movable stage, column with rack and pinion for carrying condenser, polarizer, dissecting compound body, illuminator, consisting of rectangular prism, with condensing lenses, oblique condenser, two eye-pieces, bull's eye condenser on stand, double mirror, etc., for $130.00
the objectives being extra; goniometer and micrometer, $15; brass plate and spirit lamp, for heating objects while under examination, $5; Polariscope $27.50. This microscope is the invention of Prof. J. Lawrence Smith, and is admirably adapted to the purposes for which it was more especially designed. The objectives being placed beneath instead of above the stage, the operator can readily apply his tests, acids, etc., without the hazard of injuring his objectives, or having his view obscured, by the fumes arising from

Fig. 27.

the liquid experimented with. Fig. 28 is a representation of their simple inverted microscope, the price of which is $60, without the objectives and accessories above named.

9. They also manufacture a Binocular microscope, the invention of Prof. J. L. Riddell, by which the effect of the Stereoscope is given to the view of microscopic objects, price, ...$100 to $150.

Fig. 28.



The accessories to the above Grunow microscopes, have about the same prices as those named in Spencer & Eaton's list. The prices of their objectives, will however, be found to differ, as follows:—

FIRST CLASS OBJECTIVES.

2 inch,	angle of aperture		13°,	$14.00
1 inch,	do	do	25°,	18.00
½ inch,	do	do	60°,	25.00
½ inch,	do	do	50°,	20.00
¼ inch,	do	do	95°, to 100°,	30.00
⅛ inch,	do	do	130° to 140°,	40.00
$\frac{1}{12}$ inch,	do	do	160°,	60.00

SECOND CLASS OBJECTIVES.

2 inch,	angle of aperture		10°,	$8.00
1 inch,	do	do	15°,	8.00
½ inch,	do	do	40°,	12.00
¼ inch,	do	do	65°,	15.00
⅕ inch,	do	do	90°,	25.00

The first class objectives, are adjusted for correcting the aber-

ration produced by the thin glass covers, with the exception of the 2 inch, 1 inch, and $\frac{1}{2}$ inch of 50° angle of aperture, and they are attached to the microscope by means of a bayonet joint. The second class objectives screw on an adapter, and are adjusted for a thin glass cover $\frac{1}{100}$ of an inch in thickness. The principle difference in the two classes, consists mainly in increased or limited angle of aperture. Upon application to the Messrs. Grunow & Co., or to Spencer and Eaton, a catalogue will be furnished, containing the prices of all their microscopes, accessory apparatus, and other optical instruments.

The magnifying powers in diameters or *linear measurement*, of all the above named objectives, with the different eye-pieces, average about the following, depending, in some measure upon the degree of angle of aperture of each.

EYE GLASSES.	OBJECT GLASSES.					
	2 *in.*	1 *in.*	$\frac{1}{2}$ *in.*	$\frac{1}{4}$ *in.*	$\frac{1}{8}$ *in.*	$\frac{1}{12}$ *in.*
A.	15 to 20	50 to 60	90 to 100	200 to 220	375 to 420	500 to 600
B.	25 to 30	70 to 80	120 to 130	300 to 350	600 to 680	800 to 880
C.	35 to 40	90 to 100	160 to 180	450 to 500	830 to 900	1200 to 1600

For popular use, as well as for medical purposes, and indeed for the greater part of ordinary investigations, Grunow's Educational Microscope, or the Student's Microscope of either Grunow's or Spencer and Eaton's, will be found fully sufficient; indeed, there are very few observations to which these are not adapted. A microscope should be in the possession of every family that is able to afford the purchase of one; it will always be found a useful and interesting instrument, imparting a fund of entertainment and instruction, not to be obtained by any other means; it opens a new world, and displays the most extensive scenes of creative power, wisdom and design. A parent cannot present a more valuable and serviceable gift to his son or daughter, one which will be more acceptable, than that of an instrument of this kind. With children it exercises their observing powers and instils into their minds a fondness for proper study, and a real love of nature; with the adult it is a companion, which, though a silent one, yet introduces him into the wonderful secrets of nature, and enables him to turn to profitable account those hours which might otherwise be passed in *ennui*, at the drinking saloon, gamin~
or in frivolous or degrading amusements. There is n·

ter calculated to improve the world in virtue, morals and science, preserving both sexes equally alike from temptations and iniquity, and leading all to a correct estimation of the attributes of their Maker, than an early introduction to the wonders and magnificence of nature as disclosed by the powers of a microscope. The head of every family should ponder well upon these few and incontrovertible remarks. The value of the microscope to medical men, is too well known at the present day, for me to suggest anything in its favor; for he who is unacquainted with the results of microscopic research in his profession, is far, very far behind the age, and is hardly worthy the name of physician.

It will be proper before closing this chapter, to name those opticians and microscopists of Europe, who have done much to improve both the instruments and the science of microscopy.

Mr. A. Ross, ... London.
Powell & Lealand, ... do
Smith & Beck, ... do
Pritchard, ... do
Pillischer, ... do
Salmon, ... do
Dancer, ... Manchester.
Ladd, ... Walworth.
Lister, ... England.
Wenham, ... England.
Amici, ... Modena.
Chevalier, ... Paris.
Nachet, ... do
Oberhauser, ... do
Brunner, ... do
Frauenhofer, ... Munich.
Pistor, ... Berlin.
Schiek, ... do
Ploesl, ... Vienna.
Utzschneider, etc., ...

CHAPTER III,

PRELIMINARY DIRECTIONS FOR USING THE MICROSCOPE, ACCESSORIES, ETC., ETC.

It is a popular but erroneous idea that low priced microscopes are equally as useful in making examinations as the higher priced ones. Cheap microscopes almost always produce much dissatisfaction, whether with the high or low powers, being not only devoid of distinctness, penetration, and resolution, but usually giving incorrect or distorted views of objects. It is much more economical to obtain the right kind of a microscope at first, with one or two low powers, and from time to time procure the other powers, as pecuniary circumstances will permit. He who buys a cheap microscope, soon gets dissatisfied with it, and eventually neglects attending to this kind of investigation, from a mistaken view, based upon the action of his cheap instrument, that it is either too difficult for him to manage, or that there is nothing in it.

In the selection of a microscope, whatever may be its range of powers, there are certain points in its construction, which are very essential, and should be particularly attended to. It should, in addition to the combination of lenses, forming the eye-piece and objectives, have a firm and sufficiently large stage for the objects or slides not only to rest upon, but also to move about, as may be required under the objective,—it should be at least three inches by four; a *movable stage* is not necessarily needed, for the best microscopists move their slides on *a plain stage*, by means of the thumbs or fingers, and only use the movable one on particular occasions—the greatest discoveries have been made on the plain stage. There should be a *concave mirror* to illuminate transparent objects from beneath, and a bull's eye *condensing lens* to illuminate opaque objects from above, together with an arrangement that will admit of a *fine* as [illegible] *coarse adjustment*, for the purpose of readily and a[illegible] focal distance of the objective, *without* [illegible] side or the

other. The supports of the microscope should be firm, and not too heavy, but sufficiently so to ensure steadiness, and freedom from tremor; for any vibration materially interferes with the optical performance, rendering the view very confused, and unsatisfactory. And the whole body of the microscope and its mirror, should be movable on its supports, so that it can be inclined at any angle to suit the convenience of the operator. Those microscopes which are made permanently vertical, so that one must always look from above directly downward to see an object, however excellent their optical powers may be, are very poor working instruments, fatiguing the neck, head, and eye of the microscopist; such should never be purchased for purposes of investigation.

The object-glasses should be free from any specks or blemishes, and should give a clear and distinct view of the object under examination, or in other words, they should possess a good *defining* power, likewise a *penetrating* power, by which the structure of objects may be looked into; a *resolving* power by which close markings may be distinguished according to the magnifying power of the objective,—and the *field of view* should be flat or nearly so. A good objective gives a flat, colorless field of view, and a very clear and distinct image of the object. The best object-glasses are those, each one of which possesses but one power, but which may be increased to some extent by the *eye-piece*. The most useful object-glasses are the inch and quarter inch; the former should magnify at least 40 diameters, the latter, 300. They should transmit plenty of light; the lines of objects under examination should be sharp and distinct, without any colored rings around them; and the whole field of view should be perfectly flat, every part of it being in focus at the same time. With the larger microscopes three eye-pieces are generally furnished, but for ordinary investigation one good eye-piece will be found sufficient, and it should not be of very high magnifying power. The mirror is placed below the stage, and should be so arranged that it may be moved on the rod to which it is attached to or from the stage, and also be easily inclined to any angle that may be required to illuminate an object. A plane mirror and a concave one should be attached to every microscope, and they should not be less than two inches in diameter. The bull's eye *condensing lens* may be attached to the stage or other part of

the instrument, or it may be carried on an upright rod, free from the microscope.

The above are all the parts of a microscope ordinarily necessary for scientific or other investigations, but, in some branches of microscopic study, for the purpose of facilitating and perfecting observation, various accessory instruments are used as

Fig. 29.

THE DIAPHRAGM;

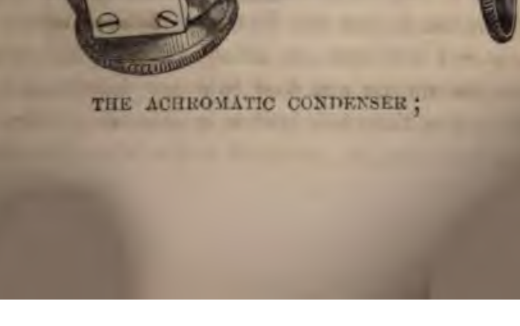
Fig. 30.

THE ANIMALCULE CAGE;

Fig. 31.

THE COMPRESSOR;

Fig. 32.



THE ACHROMATIC CONDENSER;

THE POLARISING APPARATUS;

Fig. 33.

Mounting of Polarizing Prism;

Fig. 34

Mounting of Analyzing Prism;

THE CAMERA LUCIDA;

Fig. 35.

Nachet's Camera Lucida;

OR THE STEEL SPECULUM;

Fig. 36.

Sœmmering's Steel Speculum;

Either of these last two may be used for the purpose of drawing objects on paper; they fit over the eye-piece, and require some practice to use them with advantage. Beside these are *small brass forceps*, with which to hold or pick up objects; small slender glass tubes, called *pipettes* or *dipping tubes*; *micrometer eye-piece* for measuring the dimensions of objects; and, for the purpose of holding objects under the object-glasses,

THE STAGE FORCEPS.

Fig. 37.

IN USING THE MICROSCOPE it should be placed on a firm and steady table, of sufficient height to enable the observer to make

his examinations without inconvenience or straining the muscles of the neck, and of sufficient size to hold any of the apparatus which it may be required to have within reach; a table whose top is two feet by three with a drawer or two in it, will answer all purposes; any vibrations of the table imparted to the microscope will render it of doubtful utility. Microscopic manipulations and investigations require a sufficient amount of room, as well as special arrangements; no satisfactory nor reliable operations can be accomplished where there is an extremely limited space, or where the necessary apparatus, accessories, etc., are crowded together, so as not to be readily reached.

It may be proper to remark here, that some persons on commencing microscopic examinations, are troubled with giddiness or even headache from lengthened observations,—this, however, will gradually pass away as they continue their investigations, and become more and more accustomed to them. Sir David Brewster in his work on optics, insists upon the following rules for microscopic examinations.

"1. The eye should be protected from all extraneous light, and should not receive any of the light, which proceeds from the illuminating center, excepting what is transmitted through, or reflected from the object.

"2. Delicate observations should not be made when the fluid which lubricates the cornea is in a viscid state. [This may be overcome by plunging the face, with the eyes open in cool clear water, frequently opening and shutting the eyes while in the water, and repeating the plunging process two or three times, before drying. I am aware that this mode of bathing the eyes is objected to by some medical men; but I know it to be beneficial and devoid of injury, having known hundreds of persons to pursue it with advantage, beside having practiced it myself for the last thirty-five years, with decided benefit.—K.]

"3. The best position for microscopic observations is when the observer is lying horizontally on his back. This arises from the perfect stability of his head, and from the equality of the lubricating film of fluid which covers the cornea. The worst of all positions is that in which we look downward vertically.

"4. If we stand (or sit) straight up, and look horizontally, parallel markings or lines will be seen most perfectly when their

direction is vertical; viz., the direction in which the lubricating fluid descends over the cornea.

"5. Every part of the object should be excluded, except that which is under immediate observation.

"6. The light which illuminates the object should have a very small diameter. In the day time it should be a single hole in the window-shutter of a darkened room, and at night an aperture placed before an Argand lamp. (When the sun's rays enter the hole in the window shutter, a good light may be obtained by closing the aperture with a piece of ground glass, a piece of white muslin or tissue-paper, or a piece of blue glass.]

"7. In all cases, particularly when high powers are used, the natural diameter of the illuminating light should be diminished, and its intensity increased, by optical contrivances."

A GOOD LIGHT is always necessary; in the day-time a northern light is preferable to any other, and, when possible, a white cloud opposite to the sun should be selected as the illuminating source. The direct rays of the sun must be avoided, as tending to seriously impair the distinctness of the object, causing an iridescence, or fringe of prismatic colors around all parts, beside materially injuring the eyes of the observer. Moving clouds produce variations in the identity of the light, requiring a constant change of the mirror, beside fatiguing the eye of the observer. The operator should sit with the light immediately facing him, or which is better have it on his left side, thereby aiding in preventing any extraneous light from entering the eye during an observation, as well as preventing any shading or intercepting of the rays of light, when employing his right hand in manipulating. No light should enter the eye except that which it receives through the microscope. A sky light, intercepted by trees or buildings, is improper for microscopic observations.

ARTIFICIAL LIGHT is by no means equal to day-light, though it is much better than bad daylight. There are many persons who can find time for microscopic investigations only at night, such will find an Argand lamp with a neutral tint or deep greyish blue glass chimney much better than any other. A wax candle, or camphene lamp will answer, or even a gas light, but unless the bright yellow field which they give is corrected and made white or bluish white, by a neutral tint glass chimney, it will be

found not only to injure the eyes but to materially impair the distinctness of the object.

A blue glass nearer the mirror, or between the stage and mirror, is recommended as having a much better effect in modifying the intensity and color of the rays of light, than when it is closely approximated to the flame. Dr. F. Branson recommends slides of bluish-grey glass of various shades, one of which is placed upon the stage under the glass slide bearing the object, or, the object may be placed upon the colored slide itself for examination.

Mr. George Rainey, says: "that which gives the peculiar burnish or glow to all objects when highly illuminated, whether by the direct rays of the sun, or by light proceeding from ignited matter, is due to the heating portion of the spectrum and certain colored rays. In the former case we make use of light for microscopic illumination which has been deprived of this burnish by its having passed through the clouds; and in the latter this can be equally well effected by passing the light emanating from gas or a lamp through such transparent colored media as will stop the calorific rays, and at the same time furnish the kind and amount of color necessary to form, with the colored rays of the flame, white light. The combination which I find to answer best is the following:—one piece of dark blue glass, free from any tint of red, one of a very pale blue with a slight shade of green, and two of thick white plate glass, all cemented together with Canada balsam. This combination so completely stops the calorific rays, that when the direct rays of the sun are concentrated by a bull's eye of the ordinary size upon a lucifer match with this medium intervening, it does not become ignited; and when this medium is used with a Gillett's condenser, objects illuminated by the light of a camphene lamp appear as if they were seen by a bright daylight." Slides made similar to the above, might be advantageously used instead of the ordinary ones, when viewing objects by artificial light.

A portable gas apparatus (*see fig.* 108.) with six feet of elastic tube, burner, tin shade, and blue glass chimney, can be purchased in Philadelphia, for \$5 or \$7, and will be found valuable for artificial light.

It is proper for the microscopist to acquire the [illegible] it of using either eye indiscriminately, so that he m[illegible]

unnecessarily, but may from time to time relieve one by employing the other. And he should always keep both eyes open; the habit of closing the unoccupied eye, beside confusing the other, tends to fatigue the muscles of both, and ultimately will cause them to become watery or congested, a very undesirable condition.

Fig. 108.

The eye should be placed close to the eye-piece, so that the whole field of view, will be visible, and which should always be a round disc of light; if the eyelashes be reflected from the eye-glass, the eye is in an improper position, looking upon, instead of through it. If an observation is carried on for any length of time, the least amount of light possible, should be used.

A black piece of pasteboard cut into the following shape, fig. 38, the circular orifice A being adapted over the eye-piece, will be found valuable not only in aiding the observer to keep both eyes open, but likewise to prevent any extraneous light from falling upon the employed eye during delicate investigations,—b, b, are places to receive the nose, according to which eye is used.

Fig. 38.

Too long examinations by artificial light, and especially when the field of view is colored, are decidedly injurious to the eyes, and should always be avoided; and when the light, whether arti-

ficial or daylight, is too strong, the plane mirror should be used instead of the concave one.

CLEANLINESS is very important in microscopical investigations. The glasses of the objectives and eye-pieces especially should always be kept free from dust, or *contact with the fingers*, and whenever these parts are not in use they should be placed in their cases, more especially the object glasses, which should always be returned to their cases as soon as an investigation with them, or a single sitting, is finished. Should the *eye-glasses* become dusty, they may be removed, only one lens at a time, and replacing it before another is touched;—they may be cleaned with a soft old muslin handkerchief, which is superior to any thing else when it becomes necessary to wipe them; and in all cases before wiping, first blow upon the surface of the lens, then pass a clean, dry camel's hair pencil over it, blow again upon it, and then, if required, use the handkerchief. By this course any coarse or gritty particles will be removed so that the operation of wiping will not endanger scratching of the lenses.

The same course may be used with the *object-glasses;* but in the finer microscopes, it is better never to interfere with the lenses of the objectives, except it be to pass a camel's hair brush over the exposed surface of the first or lower lens,—any dimness or other difficulty which cannot be thus removed by the brush, will be best and safest overcome by sending the objective to some manufacturer, that he may properly clean and adjust it. Many excellent objectives have been ruined by the attempts made to clean their lenses by those not conversant with the proper mode of doing it. The less objectives are rubbed or cleansed the better will it be for them; and they will but seldom need cleaning if they be placed carefully in their cases immediately after using them.

After using the microscope, it should be returned to its case, rather than be allowed to remain exposed to the dust; but as this is a very troublesome course, frequently preventing one from making observations, from the instrument thus being unhandy, it is better to allow it to remain on the table, covering it with a glass shade, or with a pasteboard box, or long bandbox made for the purpose; being careful that the edges of the glass or box fit closely around the table so as tr [illegible] ll dust; and to facilitate which, a strip of cloth a [illegible] that part of the table with which the rim [illegible] in con-

tact. This course will be found especially useful, when the microscope is used every day. Great care should likewise be taken not to injure the object glasses by bringing them in contact with the glass slides, covers, objects, or fluids under observation, a thing which is apt to occur with a beginner, but which it is very important to avoid.

All glass slides, covers, pipettes, etc., should be washed in the cleanest water immediately after use and returned to their places; a person who neglects these points cannot make a reliable microscopist, and all instruments must be very carefully cleansed and preserved from rust, or they will soon become useless.

In the investigation of any object it is always better to begin with a low power which will give its general characters; after which the minute details may be brought out by the higher powers. The lower powers will also be the best when a very minute object is on the slide, for the purpose of bringing it to the center of the field that it may be subsequently viewed with a higher power.

The more powerful eye-glasses, especially when used with the higher powers, occasion a diminution of light, as well as a want of distinct and sharp definition; hence, instead of using them to increase the magnifying power, it will be found better to use the eye-glass of low power, and change the object glass, whenever this can be done. There may be occasional exceptions to this rule.

The FOCAL ADJUSTMENTS will be made according to the construction of the instrument; if there is a coarse, and fine adjustment, the former will answer for low powers, the latter must be used with the higher. With the high powers more particularly, objects which are not perfectly flat will only have those parts in sight at any one time, which are on the same plane or level, and to see other portions of them, it will become necessary to change the focus more or less, according to the peculiar shape of the object, or of its parts. Hence, from not knowing this fact, many persons in viewing a round, concave, convex, or rough object, are disappointed because they do not see all the parts equally distinct alike.

Objectives of high angular aperture, are materially affected in their power of distinct definition and resolution, by the thin glass covers, or when the object is immersed in a fluid; hence objectives have an adjusting arrangement, called *Compensat*

Mr. Wenham gives the following mode of using it:—"Select any dark speck or opaque portion of the object, and bring the outline into perfect focus; then by means of the fine adjustment, move the objective briskly backward and forward in both directions from its position, so as to carry the object out of focus each way. Observe the expansion of the dark outline of the object, both when *within*, and when *without*, the focus. If the greater expansion or coma, is when the object is *without* the focus, or furtherest from the objective, the lenses must be placed further asunder, moving the slide toward the mark "uncovered."

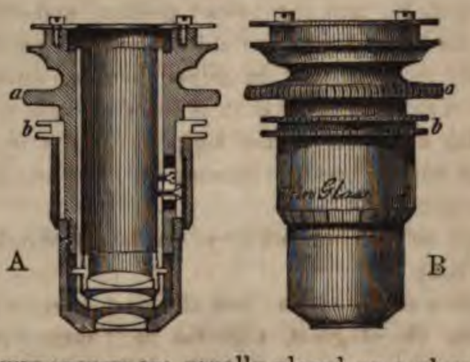
"If the greater coma is when the object is *within* the focus, or nearest to the objective, its lenses must be brought closer together, moving the slide toward the mark 'covered.' When the object glass is in proper adjustment, the expansion of the outline is exactly the same both within and without the focus." With objects, however, which present a set of distinct dots, or other markings, as "test objects," he says,—"if the dots have a tendency to run into lines when the object is placed *without* the focus, the glasses must be brought closer together, by moving the slide toward the mark 'covered;' on the contrary, if the lines appear when the object is *within* the focus, the slide must be moved toward the mark 'uncovered.' When the angle of aperture is very wide, the difference in the aspect of any severe test under different adjustments becomes at once evident; markings which are very distinct when the correction has been exactly made, disappearing almost instantaneously when the screw collar is turned a little way round."

The simple method of Mr. Powell will answer for all ordinary purposes; the object glass, adjusted to "uncovered" is to be focussed to the object; its screw-collar is next to be turned, until the surface of the glass cover comes into focus, as may be perceived by the spots or striæ by which it may be marked; the object is then to be again brought into focus by the fine adjustment. Among those objectives not furnished with the adjusting or compensating arrangement, it will usually be on account of their small angle of aperture, and consequently the above remarks have no reference to them.

The best method of mounting ob[illegible]s, with the compensation or adjusting arrangeme[illegible] Mr. Wenham's plan, and which is now ado[illegible]cope makers.

Fig. 39, represents at A a longitudinal section of such an arrangement, and at B the exterior appearance of the object-glass. The anterior lens at A, is fixed permanently, while the middle and posterior lenses are moved up and down by means of a screw passing through a slide in the tube holding the anterior lens; this screw is attached to a milled-head, revolving collar *b;* when this collar is turned, the tube carrying the middle and posterior lenses is conveyed from or toward the anterior lens, according to the direction in which the collar is turned. By this means, instead of the old vexatious method of making the adjustment, the observer arranges the compensating apparatus for uncovered objects, (which is marked upon the objective)—obtains as good a focus for the covered object as he can, and then merely turns the revolving collar to the right or left, as the case may require, to obtain a perfect focus. Some makers graduate the points between "covered" and "uncovered," which renders it more convenient in many instances.

Fg. 39.



Transparent objects are usually placed on a glass slide, and, when in fluid, or when a high power is used, covered with thin glass; the slide is then laid upon the stage of the microscope, and the object brought to a proper position under the objective, by means of a movable stage, or by the fingers. The light is then reflected upon the under surface of the slide, and transmitted through the object by means of the mirror, which must be moved in various directions until a good light is obtained. Animalcules may be viewed in this manner, or, still better, in the animalcule cage, instead of on a slide.

Generally it is better to obtain the proper light first, and when

the field of view presents the clearest and brightest disc, place the object upon the stage, under the object-glass, and carefully bring this to a correct focus upon the object. In many instances, the slide will require to be moved about by the fingers, for a little time, or by the movable stage, before the object can be brought to the center of the field of view.

The young observer must be careful not to be deceived by air globules, when examining objects in fluid; and with which he will frequently meet. They appear as black rings with a luminous center, the same as globules of oil, but may be distinguished from these latter, by altering the focus; thus, if the object-glass be *brought closer* to the dark ring the air-globule assumes a more luminous appearance, while an oil-globule would appear darker; on the other hand, if the objective be elevated above the focus, the air-globule assumes a darker appearance, while the oil-globule appears lighter. A little attention to these points will soon enable one to recognize an air-globule from one of oil at once.

Opaque objects are generally placed on a black slide of glass, wood, or paper, brought to a proper position under the objective, and illuminated from above by the Condensing, or Bull's eye lens. These are, for the most part, examined by low powers; the lens is so arranged in front of, or at the side of the object, as to intercept and bring a cone of rays of light to a point upon that part of the object which is under examination. Direct sunlight must always be avoided.

The convex side of the bull's eye condenser should be placed toward the lamp or source of light, and the plane side toward the object under examination; and the condensing lens should be placed so near the stage, that all the light falling on it may be brought into a focus upon the object. When a lamp is used, it may be from ten to fifteen or twenty inches distant from the condenser. It is very seldom that the reverse of this position of the lens will be required, and then in those cases only where parallel or diverging rays of light are required for the purpose of illuminating a large surface. The Lieberkuhn, a small silver concave mirror attached to the objective for the purpose of throwing rays of light upon opaque objects is not much used by microscopists of the present day.

In all microscopes, when using an [illegible] as or high power, it, together with the [illegible]

vated or turned to one side previous to removing the object (as the instrument will permit,) in order to prevent the front lens of the objective from coming in contact with the object, and thereby becoming injured. Indeed it is an excellent practice to turn the compound body and objective aside, or to elevate them, according to the character of the instrument, whenever objects are removed from the stage for some alteration, or for the purpose of placing new objects under the object-glass—a little attention to this point will soon render it a natural habit.

A few words relative to the use of the *camera lucida* may not be amiss. This must be adapted to the peculiar form of the eye-piece, on which it is to be placed, and it must be remembered that it is chiefly intended for taking the outline of objects. The proper focus of the object must first be had, then arrange the compound body of the microscope in a horizontal position, and, if it has not been placed on previously, now fasten on the camera, and place a piece of white paper on the table immediately under the camera. The observer will then place his eye over the uncovered *edge* of the prism, and look through it *down upon* the paper; he must not be discouraged if he sees nothing at first, as it requires a little practice to accomplish this; if, however, he cannot see a circle of white light upon the paper, with the image of the object within it, after looking through the prism in various directions, he may slightly turn the camera round on the eye-piece, or if it is arranged for such movement the prism may be revolved on its axis, until the field is brought into view; and similar movements may be given, when only part of the field is seen, in order to render the whole visible. It may be that the motion of the apparatus will somewhat alter the focus, but this can be easily remedied by the fine adjustment.

The paper should be about as far from the camera as the object is from the field lens of the eye-glass; if it be removed to a greater distance the object is rendered larger but less clear and distinct. It should be kept in its place, by pins or wafers. The lead pencil used to trace the outline of the object, should not be too soft, and must be brought to a fine point, in order to produce delicate marks, and any shading or thickening of lines can be done subsequently. A very fine camel's hair brush may also be used, especially when the object is quite delicate, the color being either India ink, Sepia, or Prout's brown; the latter is the best.

Having arranged the instrument and paper, the observer must obtain as good a position as possible for seeing the image distinctly on the paper and the pencil point at the same time, and when this is obtained the eye should be held as steadily as possible until the outlines have been completely traced; any change or faulty position of the eye will alter the place of the image on the paper and render the tracings very irregular and erroneous. The drawing should be made with a very fine sharp-pointed pencil, taking considerable pains to make the outline as true to nature as possible. It is necessary that the paper and the object be equally illuminated; sometimes it will be required to throw a stronger light upon the object than upon the paper, or the pencil point will not be distinctly seen; again, it will sometimes be found advantageous to shade the paper by placing a thin blind or screen between it and the light. Practice, however, will soon determine these points. Sometimes, the pencil point will suddenly disappear, owing to a change in the axis of the eye; when this occurs, the pencil should be kept stationary upon the paper, and the eye moved about until the pencil is again seen, and the marks already made be found to correspond with those of the object, and then the eye should be kept steadfastly fixed in the same position until the tracing is finished.

It requires some practice before the observer will be able to trace well, but he should persevere and not allow himself to be foiled in his first attempts. His best plan will be to take some object with a well defined margin, and trace its outline by a low power, repeating it until it is perfect, and so continue until he can use the higher powers in this way. "The importance of being able to make accurate delineations of the microscopical characters of tissues, animalcules, microscopic plants, and especially of morbid growths, can hardly be sufficiently dwelt upon, and every student should learn to draw as soon as possible."

In order to facilitate seeing both object and pencil with the same degree of distinctness, one or two lenses, or colored glasses are attached to the cameras of most microscopes.

When the drawing will require several sittings the utmost care should be taken that neither the microscope, object, nor paper are moved in the least during the intervals, and each time, previous to recommencing the tracing, the eye should be

fully about, until all the parts of the object and the tracing are found to be in perfect approximation.

The beautiful and accurate drawings and engravings of many objects met with in works on the microscope, are not only the result of much practice and perseverance, but are frequently perfected by the artist, who changes the focus of the objective, as he proceeds in his drawing, to bring into view the several parts of an object. So that one must not be disappointed in having to change the focus of his object-glass in order to observe all the characters marked out in the engraving of many objects presenting a globular or irregular surface, and it is one test of a good object-glass, that all parts of an object on the same plane are seen equally distinct, while any elevation above, or depression below this plane is more or less indistinct according to its distance from the plane. Objects which are perfect and most accurately mounted, or which are seen with the greatest degree of distinctness, are more generally selected as the ones from which drawings are made.

The camera-lucida may also be used as micrometer. All that is necessary is to have a *stage micrometer* of known value under examination, and its magnified lines are to be accurately traced upon the paper. These lines may be subdivided to almost any extent, and thus a scale obtained, by which images drawn under the same power, and at the same distance beneath the camera, may be measured.

Mr. Henry Coles believes that the following method of using the camera lucida with a stage micrometer answers the requisites of cheapness, facility, and accuracy;—"Place a stage micrometer in the focus of a microscope; adapt a camera lucida, and then accurately trace on a piece of card board, one, two, three, or more of the divisions. Subdivide each division by tens, or (if need be) by hundreds; then place the object to be measured in the focus of the microscope, and observe, through the camera lucida, the number of divisions it extends over on the card board. For instance: I have an object-glass and eye-piece which, with the length of tube in my microscope, magnify 500 diameters; and on looking with these at a stage micrometer, with 200 divisions to the inch, I find that each division occupies 2½ inches on a card-board placed underneath the camera lucida on the table. I mark one of these spaces on the card board, and divide it into

25 parts; that is into tenths of an inch, and consequently, each tenth of an inch on the card-board corresponds to the 5000th part of an inch of an object in the focus of the microscope, obviously, also, if instead of card board, I use a slip of ruled glass, with a hundred divisions to the inch, each division will then correspond to the 50,000th part of an inch."

"For convenience of calculation, it is desirable that each division of the micrometer should coincide with the lines of inches, or large fractional parts of an inch, on the card-board; and this is easily effected when the microscope is furnished with a draw-tube; but when the latter is wanting, the same point may be gained by elevating the card-board on a book or some kind of stage; of course, always taking care that the distance of the camera-lucida from the card-board should be precisely the same, when an object is to be measured, as it was when the divisions were marked on the card-board. The ease of this method, also, in accurately determining the magnifying power of any combination of lenses and eye-pieces one may happen to possess, will be evident to those attempting to practice it. The cost of a camera lucida is very trifling, and there would be no need to purchase a stage micrometer, if one could be borrowed for a short time, "(a bad plan, however, to borrow)" since a piece of card board, once accurately marked for each power in the above manner, would supersede its further use."

The instruments necessary for the preparation of objects, are, for animalcules, diatoms, desmidiæ, etc., *vials*, which may be attached to the end of a stick to collect or dip up water containing these objects—*bottles* in which to preserve them at home,—*glass-pipettes*—one or two *needles* in handles,—*small brass forceps*,—one or two *watch glasses*—and *animalcule cage* or *compressor*. For preparing dissections, other instruments are needed, as, *dissecting needles* in holders, (straight and curved,) *Valentin's knife* or a *microtome*, *straight* and *curved forceps*, *small scalpels*, *fine syringes* for injections, *small water-bath*, *watch-glasses* of various sizes, etc. A pair of *thin brass forceps* should always be kept solely for removing and laying on the thin glass covers.

Upon examining an old shaving brush some of its bristles will be found split into two or three parts; several of these being selected and mounted in the end of light sticks, will be four

useful in removing many small objects; for, by placing the split end of the bristle near the desired object, when on a slide or watch-glass, and pressing upon it, the split parts will separate like a forceps, and the object may be caught between them and removed to a slide or elsewhere. Some little care and practice will be required in order to operate rapidly and successfully with these *mounted bristles.*

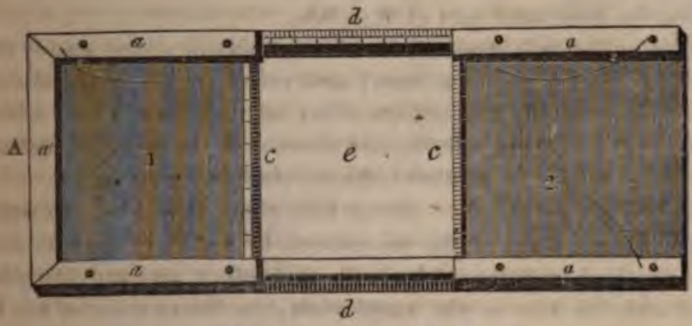
Dr. A. M. Edwards, of New York, recommends a very cheap and excellent contrivance for *illuminating objects* under the microscope; it consists of an ordinary glass slide, to the center of one surface of which the plane surface of a plano-convex lens is attached by means of Canada balsam. Lenses of half inch, and quarter-inch focus are the most useful but different powers may be used. This slide is placed upon the microscope stage with the lens downward; on the upper flat surface the object, or a slide containing it, is placed. This gives an even white light over the whole field of vision, and is particularly useful on dull days. It brings out the markings of the Diatomaceæ very distinctly. If a dark stop be placed exactly in its center, or a small disc of black paper be pasted on the center of the slide, it shows the objects clearly and beautifully on a black ground. It forms a cheap substitute for the achromatic condenser, and parabolic illuminator. These lenses are small, the largest not exceeding half an inch in diameter.

For illuminating opaque or transparent objects on a black-ground, Mr. Wenham has proposed a small triangular prism, each of whose plane surfaces is about one fourth of an inch square, "to be placed beneath the object, so that one of its plane surfaces is in contact with the under surface of the slide carrying the object. The light is refracted so highly, that none passes directly through the object; but being thrown at the proper angle upon the under surface of the thin glass which covers the object, is entirely reflected from thence upon the object itself, which is thus highly illuminated. In employing these instruments, the light should be reflected from the plane mirror."—*Beale.*

As microscopists frequently send their specimens to each other by mail, it becomes necessary that an *indicator* should be used, for the purpose of at once bringing the specimens in the field of view without loss of time. The following Indicator *fig.* 40 which I recommend to the notice of microscopists will be found to answer

an admirable purpose, it is manufactured at my request by Mr. Jas. Foster, of Cincinnati, and may be obtained with the graduations divided into $\frac{1}{50}$ths of an inch, or for the higher powers, into $\frac{1}{100}$ths. For accuracy, it is important that each indicator be graduated exactly alike from the center of the scales. Price $5.00.

Fig. 40.



KING'S UNIVERSAL INDICATOR.

A is a flat, smooth plate of brass or other substance, about 3 ½ inches in length, 1 ½ inches in width, and sufficiently thick to be firm and not springy; about $\frac{1}{16}$ inch. *a a a a a'* are five strips of brass, about $\frac{3}{16}$ of an inch wide, and $\frac{1}{16}$ of an inch in thickness, which are screwed upon the plate A, (after this has been properly graduated, etc.,) and which are designed to contain and hold the glass slides when under examination. The width of the space included between the horizontal slips is about 1 $\frac{1}{8}$th of an inch, so as to hold slides which may occasionally exceed an inch in width.

2, 2, 2′, are pieces of watch-spring inserted into the slips, as shown, for the purpose of holding the glass slide firmly against the sides of the slips on which they press; 2′ being a strong spring to press the slide strongly against the left side of the Indicator.

e, is a quadrangular opening cut out of the plate A, being 1 ½ inch in length, and 1 ⅛ inch in width; the center of this aperture is exactly 1 ½ inch from the inner surface of the left hand slip, *a′*.

c, c, these inner edges of the aperture in the plate A, are bevelled, and on each bevel is marked a scale graduated into $\frac{1}{50}$ths, or $\frac{1}{100}$ths, of an inch, and which graduations must be placed

exactly opposite to each other; these graduations give their indications when in conjunction with the line from left to right on the plain stage of the microscope.

d, *d*, these outer edges of the plate A, are bevelled and graduated similar to *c*, *c*.; which graduations are to be read with the vertical line on the stage of the microscope. In order not to interfere with these readings, the slips *a*, *a*, *a*, *a*, are not carried across the graduated part of the plate.

This indicator is intended for all microscopes whose stages are not less than 2 ½ inches square; and microscopists in possession of one may readily find objects either of their own, or on slides forwarded by others, who furnish them with the recorded indications ascertained by another indicator similarly constructed.

Its use is very simple. In the first place, it will be necessary to prepare the stage of the microscope, by marking upon its surface two lines at right angles with each other, and running parallel with the sides of the stage plate, the intersection of which lines will be exactly in the center of the field of the highest power of the microscope; and a sliding spring clip or ledge should be attached to the stage, in order to support the indicator when the microscope is inclined to any angle. The closed end of the indicator, 1, must always be placed on the left side of the stage; and the glass slide should be marked or numbered on that end of it which must be placed against this left side of the indicator.

Placing the glass slide in the indicator, this may be moved about, and any object be brought into the center of the field; then by observing the number of the graduations lying immediately over the lines on the stage, and recording them, we may, at any subsequent time, readily bring the same object into view, by again placing the recorded graduations of the indicator directly over the stage-lines.

It will be better to have a universal method of recording,—thus, graduations corresponding to the stage-line running from left to right, forming the *denominator*, and those which are read with the vertical stage-line forming the *numerator*. If but few objects are on a slide, their situation in numbers, forming a fraction, may be attached to it, by pasting on it a piece of paper containing the record. This, however, will prove very inconvenient and unsatisfactory; and a recording book arranged as follows, for preserving the situation of objects on slides, with each object-

ive, will be found an excellent method. Each page may be large enough for recording 50, 100, or 200 objects.

No. of Slide.	Names of Objects.	OBJECT GLASSES.						REMARKS.
		2 *in.*	1 *in.*	$\frac{1}{2}$ *in.*	$\frac{1}{4}$ *in.*	$\frac{1}{8}$ *in.*	$\frac{1}{12}$ *in.*	
3.	Pleurosigma	10	10	10	$9\frac{3}{4}$	$9\frac{3}{4}$	$10\frac{1}{4}$	Aug. 7th, 1856.
	Angulata,	37	37	37	$36\frac{3}{4}$	$36\frac{3}{4}$	37	From Prof. J. W. Bailey in exchange
	Biddulphia	20	20	20	$19\frac{3}{4}$	$19\frac{3}{4}$	$20\frac{1}{4}$	for, etc.
	Pulchella,	10	10	10	$9\frac{3}{4}$	$9\frac{3}{4}$	10	A perfect specimen
	Pleurosigma	3	3	3	$2\frac{3}{4}$	$2\frac{3}{4}$	$3\frac{1}{4}$	
	Spenceri,	6	6	6	$5\frac{3}{4}$	$5\frac{3}{4}$	6	

$15.

$60.

CHAPTER IV.

METHODS OF MEASUREMENT.—TEST OBJECTS.

EVERY microscopist should understand how to ascertain the power of his various objectives and eye-glasses, as well as to measure the size of objects, and for which an ivory rule graduated into inches, tenths and hundredths, and a *stage micrometer* will be required, as well as an *eye-piece micrometer*. The value of each objective, and of each eye-piece with the several objectives should be ascertained, and recorded in a table, for ready reference, arranged as hereafter shown.

To determine the power of the combination of each eye-piece and objective, the stage micrometer is to be placed upon the stage with its lines under the object-glass, and the ivory scale placed outside upon a level with it, so as to be seen by the left eye when the right is occupied in observing the stage micrometer lines through the microscope; adjust the focus, and also the lines on both the scale and the micrometer, so that they shall be parallel with, and run into each other, when viewed in the manner about to be described. Then keeping both eyes open, with one, (usually the right), look through the microscope to see the lines on the stage micrometer, and with the other look at the ivory scale; while looking steadily thus for a few minutes, if the eyes be properly placed, the disc of light in the field of view, together with the micrometer lines will be seen to project upon the scale, so that the lines on each can be viewed at one and the same time, and some of them be seen to pass into each other, as it were, making the lines on the stage micrometer and on the ivory scale continuous with each other, so that it will be an easy matter to count how many divisions of the ivory scale lie between one or more spaces of the stage micrometer.

Thus, suppose the stage micrometer is divided into $\frac{1}{100}$ths of an inch, and one of its spaces occupies just one inch of the scale, then the diameter is 100 because $\frac{1}{100}$th of an inch is made to appear

as large as an inch; if it be the $\frac{1}{50}$th of an inch, and one space occupies two tenths of an inch on the scale, the diameter is 100. The diameter can always be ascertained by multiplying the size of the divisions of the stage micrometer by the numerator of the fraction of parts of an inch to which one or more of them correspond, [when magnified and viewed as above described], on the scale, and dividing this result by the denominator, thus; suppose the observer has not a scale of tenths, but an ordinary one of sixteenths, and his stage micrometer is divided into 500ths of an inch; on an examination, he finds one of the magnified divisions of the micrometer equal to an inch and three eighths on the scale. By reducing this to eighths to facilitate the calculation, it will give $\frac{11}{8}$; now multiply the size of the micrometer divisions, 500, by the numerator, 11, which gives 5500, and this being divided by the denominator, 8, gives 687½ diameters, equal to 472.656 times superficial measure. But if, instead of one micrometer division occupying, when magnified, the inch and three eighths, as above, suppose it requires three of them to equal this measure on the scale; then three micrometer divisions will be equal to 687½ diameters, and one of these divisions will be just one third, equal to 229 + diameters.

Not only must the magnifying power of the different object-glasses, with each of the eye pieces be known, but, with those microscopes which have draw-tubes at the eye-piece end, the distances to which the draw-tube is moved must likewise be known, because every variation of distance between the eye-piece and objective changes the diameter.

THE VALUE OF EACH SPACE IN THE MICROMETER EYE PIECE WITH THE VARIOUS OBJECTIVES must also be ascertained, and which is effected by comparing the spaces of the eye piece with those on the stage micrometer. Thus, suppose the stage micrometer to be divided into 500ths of an inch, and ten of the micrometer eye-piece spaces occupy one of the stage micrometer, then each space of the micrometer eye-piece will be the 5000th of an inch; or, if four of them occupy one space of the stage micrometer, each division of the eye-piece will be the 2000th of an inch. The value of the spaces of the stage micrometer will vary with the power of the object-glass, and the distance to which the draw-tube, if present, is moved, so that it must be determined in each case respectively, and recorded.

The value of each space in the micrometer eye-piece will also vary with each objective. Thus, suppose the stage micrometer to be divided into five hundredths of an inch, and, that with an inch objective, three of the micrometer eye-piece divisions occupy just one of the stage micrometer spaces; then with this objective, three micrometer eye-piece divisions are equal to $\frac{1}{500}$th of an inch, and one of these divisions is equal to the one third of this, or the $\frac{1}{1500}$th of an inch.

Again, suppose we remove the inch objective, and employ the quarter inch, and with this find that it requires twenty of the micrometer eye-piece divisions to occupy just one of the stage micrometer spaces; then, when measuring with this object-glass, twenty micrometer eye-piece divisions are equal to $\frac{1}{500}$th of an inch, and one is equal to the one twentieth of this, or the $\frac{1}{10.000}$th of an inch.

Or, suppose the stage micrometer to be divided into five hundredths of an inch, and it requires five and a half divisions of the eye-piece micrometer to occupy one division of the stage micrometer; reduce the included divisions of the eye piece into halves, which would make eleven, and multiply this by the measure of one division of the stage micrometer, (500), which would make fifty-five hundred the value of half a space in the micrometer eye-piece, when used with the particular objective employed in the operation. One half of this, (twenty seven hundred and fifty,) will in this instance be the value of one space in the micrometer eye-piece.

In measuring an object, the micrometer eye-piece must be so placed that one margin of the object corresponds with one of the micrometer lines, and then the distance of the other margin can be counted off. Thus, suppose each space in the micrometer eye-piece be $\frac{1}{20.000}$th of an inch, and the object occupies two and a half spaces or divisions, it will then be the $\frac{1}{8000}$th of an inch long; this is readily ascertained by reducing the whole measurements to halves in order to facilitate the calculation; thus, in two and a half spaces there are five halves—half a space in the micrometer eye-piece is equal to $\frac{1}{40.000}$th of an inch, which divided by the five halves occupied by the object, gives its measure $\frac{1}{8000}$th of an inch.

Or, if each eye-piece division be $\frac{1}{10.000}$th of an inch, and the object occupies ten of them, it is $\frac{1}{1000}$th of an inch long; and which measurement is obtained by dividing the measure of one micrometer space by the number of spaces occupied by the object.

Or, should it be preferred to set down the diameter in decimals, by adding ciphers to the ten, and making it the dividend, and 10.000 (the value of one micrometer eye-piece division, with the particular object glass employed,) the divisor, it will give the diameter as .0001.

The table above alluded to for recording these measurements of the lenses of a microscope should be constructed as follows, so as to show the linear and superficial measurement of the eye-pieces with the several object-glasses, and the value of the micrometer spaces in fractions of an inch, and in decimals.

Magnifying Power of the Object-Glasses, with their Eye-Glasses in Diameters and Superficially.

Eye-Glasses.	OBJECT GLASSES.				
	2 in.	1 in.	½ in.	¼ in.	⅛ in.
A.	20 400	60 3600	100 10,000	220 48,400	420 176,400
B.	30 900	80 6400	130 16,900	350 122,500	670 448,900
C.	40 1600	100 10,000	150 22,500	480 230,400	900 810,000
Micrometer	25 625	70 4900	120 14,400	300 90,000	350 122,500
Value of each space in the micrometer Eye-Piece, with the various Object Glasses.	$\frac{1}{400}$ 0025	$\frac{1}{970}$ .001031	$\frac{1}{1600}$ .000625	$\frac{1}{4300}$ .0002325	$\frac{1}{9000}$ .0001111
	5=$\frac{1}{80}$ in.	5=$\frac{1}{194}$ in.	5=[illegible] in.	5=[illegible] in.	5=$\frac{1}{1800}$ in.

The decimals are obtained by making the value of each space the divisor, and ten the dividend, adding ciphers to it as the division proceeds, thus

$$400 \overline{)\begin{array}{r} 10. \\ 100 \\ 1000 \\ 800 \\ \hline 2000 \\ 2000 \\ \hline \end{array}} \; .0025$$

In this country and England the inch is usually taken as the standard of measurement; on the continent of Europe, lines, parts of a line, or millimetres are employed for a similar purpose. When fractions of a millimetre are adopted, it is usually signified by the addition of mm. to the figure or figures.

PARTS OF AN INCH.

a Paris line = .08815 or $\frac{8}{90}$ of an inch.
a metre = 39.37100 inches, or 3.281 feet.
a centimetre = .39371 do or a little less than $\frac{2}{5}$ of an inch.
a millimetre = .039371 do or a little less than $\frac{1}{25}$ of an inch.

To CONVERT PARIS LINES INTO ENGLISH MEASURE, multiply the numerator of the fraction $\frac{8}{90}$ by the number of Paris lines stated, or divide the denominator of the fraction by the same number, or multiply the number .088815 by the number of lines and parts of the same.

To CONVERT MILLIMETRES INTO ENGLISH MEASURE, multiply the number .039371 by the number of millimetres and parts of the same, the quotient will be the equivalent measure in decimal parts of the English inch.

The following tables of comparative micrometrical measures are given, as they may be useful for reference.

Millimetre.	Paris Lines.	Vienna Lines.	Rhenish Lines.	English Inches.
1	0.443296	0.455550	0.458813	0.0393708
2.255829	1	1.027643	1.035003	0.0888138
2.195149	0.973101	1	1.0071625	0.0864248
2.179538	0.966181	0.992888	1	0.0858101
25.39954	11.25952	11.57076	11.65354	1

TABLE FOR CONVERSION OF FOREIGN INTO ENGLISH MEASURES.

	MILLIMETRES. into English Inches.	OLD PARIS LINES. into English Inches.	PRUSSIAN LINES. into English Inches.
1	.039370	.088815	.085817
2	.078741	.177630	.171633
3	.118112	.266445	.25745
4	.157483	.355260	.343267
5	.196853	.444075	.429083
6	.236224	.532890	.51490
7	.275595	.621705	.600717
8	.314966	.710520	.686532
9	.354337	.799335	.77235

"In the last table the numbers in the first or left hand column correspond to the denominations expressed in the head or uppermost line of the three broader columns, while the fractions opposite these numbers denote their values in parts of the denominations of the lowermost head line. Thus, 1^{mm} = 0.039370 Eng. inch; 3^{mm} = 0.118112 Eng. inch; 2 Prussian lines = 0.171633 Eng. inch, etc. In using this table, the decimal fraction to be con

verted into parts of an English inch must be broken up into its decimal parts, and each valued separately from the table; thus, to convert 0.75^{mm} into a fraction of an English inch—

$$\left.\begin{array}{l} 0.7^{mm} = 0.0275595 \\ 0.05^{mm} = 0.00196853 \end{array}\right\} \text{(by the table).}$$

$$0.75^{mm} = 0.02952803 \text{ Eng. inch.}$$

"The only circumstance which requires attention in the use of this table is the position of the decimal point. Thus, in the above measure of 0.75^{mm}, which, when broken up, makes 0.7^{mm} and 0.05^{mm}, if the first value (0.7) had been 7.0, the value in Eng. inch. would have been, according to the table, 0.275595 Eng. inch; but this is ten times too much, or = 7 whole millimetres; hence the shifting of the decimal point, etc. To express the mode of proceeding by rule,—the decimal point in the fraction of an English inch given by the table should be shifted to the left and as many ciphers added as there are decimal places in the foreign measure."—*Mic. Dict.*

Whenever figures of objects are given, the magnifying power with which they are drawn should always be expressed in numbers near the figures; and the microscopist should acquire the habit of noting the power of the objective, as well as the dimensions of all objects examined.

No microscope is perfect for use unless it has a glass stage micrometer, and a micrometer eye-piece. And those student's microscopes which have inch and quarter inch objectives, should also have a glass stage micrometer divided into spaces the value of the two hundredth, or two hundred and fiftieth of an inch, and also a micrometer eye-piece; or, such an arrangement of the eye-piece furnished with the instrument as will enable the student to slide in at pleasure an accompanying graduated glass scale, and thus be enabled to convert his eye-piece, at will, into a micrometer eye-piece.

Test objects are microscopic objects used merely to determine the value of the object-glasses as relates to distinctness and resolving power, and in the examination of which it frequently becomes necessary to employ oblique light, condensers, etc. There are many objects of this kind, a few of which will be noticed here.

For 2 inch, or 1 inch object-glasses, any opaque object may be

viewed, as an injected preparation, also the hair of a mouse, of a bat, the pygidium of the flea, etc.

For $\frac{1}{2}$ inch objective, the hair of the dermestes, the coarser scales of Lepisma Saccharina, a dark scale of Podura, etc.

For $\frac{1}{4}$ inch, the hair of Dermestes, scales of the Hipparchia Janira, the smaller scales of Lepisma Saccharina, the scales of Podura, the filaments of Didymohelix, a confervoid algæ, and the scales of Pontia Brassicæ, or cabbage butterfly.

For $\frac{1}{8}$ inch, the paler scales of Podura, the scales of Pontia Brassicæ, the salivary corpuscles, scales of Polyommatus Argiolus, Navicula (or Pleurosigma), Hippocampus, Navicula (or Pleurosigma) Spencerii, etc.

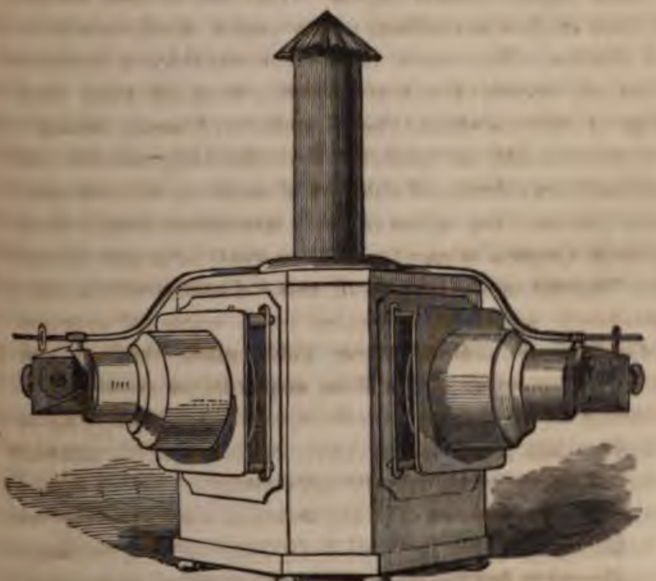
For $\frac{1}{12}$ or $\frac{1}{16}$ inch, the filaments of Didymohelix mounted in balsam, Navicula (or Pleurosigma) Spencerii, Grammatophora, *Nobert's test*, the primitive fibrillæ of muscular fiber, etc.

These objects should appear with well defined margins, and the lines or dots according to the power used, should be clear, and distinct. Too much balsam, or too thick a cover over the object will prevent the best objective from showing them well. Hairs of animals should be mounted in Canada balsam; scales of insects should be mounted dry; the Didymohelix should be mounted in a solution of chloride of calcium, or in balsam for the lower powers; the valves of the Diatomaceæ should be mounted dry or in Canada balsam, as well as fossil infusoria, foraminifera, etc. The delicate markings on those diatoms which are used as test objects, and which require large angle of aperture, high power, proper oblique light, good manipulation, and great patience, to render them visible, are as follows:—

	LINES IN $\frac{1}{1000}$ OF AN INCH.
Pleurosigma strigilis, marine	34 to 36
Pleurosigma strigosum,	44 to 80
*Pleurosigma Hippocampus,	30 to 42
Pleurosigma Spenceri,	50 to 55
Pleurosigma liniatam,	60
Pleurosigma angulatum,	60 to 70
Pleurosigma fasciola,	64 to 90
Pleurosigma littorale,	24
Pleurosigma elongatum	48
Pleurosigma obscurum,	75
Pleurosigma macrum,	85
Nitzschia sigmoidea,	85
Navicula rhomboides,	85
Navicula arcus,	130

*The genus "Pleurosigma" of Prof. W. Smith, includes those *Naviculæ* whose frustules have a sigmoid curvature, resembling the letter *f*,

Mr. John Gorham recommends the following preparation "for the production of transparent membranes for microscopic purposes, by means of which impressions of very beautiful or very rare specimens can be multiplied at pleasure. It presents the minute tracery observed on the surface of many opaque objects in a transparent form, and bids fair, also, to put us into possession of the general configuration on the surface of certain minute fresh vegetable structures which become shrivelled, and their beauty obliterated in drying. A few chips of red Sanders wood are to be shaken up in a drachm or two of good collodion; the surface of the object is then to be painted over four or five times, and in less than ten minutes the flake or cast of collodion can be peeled off, and mounted on a slide under a thin cover as a *dry preparation.*"



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CHAPTER V.

COLLECTION AND PREPARATION OF DIATOMACEÆ, DESMIDIÆ, AND FOSSIL VALVES OF DIATOMS, ETC.

THE chief attraction of the DIATOMACEÆ to microscopists, lies in the structure of their siliceous coverings or valves, the appearance of which will vary according to their structure, their mode of preparation and mounting, and the manner in which they are examined. It will frequently be the case, that with a sufficiently powerful objective the markings on the valves may be seen very distinctly with the ordinary direct light of the mirror; while with other objects no markings will be visible, at least until the mirror is moved to one side that the light may be thrown obliquely upon them. Object glasses of large angular aperture are the best adapted for distinguishing the more difficult markings, but those who do not possess these, may frequently render the markings apparent with a moderate angle of aperture by using a central stop, (a dark disc one or two lines in diameter) placed exactly in the center, of both the condenser and the object glass.

In collecting diatoms, several wide mouthed vials, of the capacity of an ounce or two will be required, in order to hold each gathering separate from the others, and when filled they must be corked so that none of the water will be spilled, and thus be a means of losing some valuable specimens. I find it a very good plan to place a number of wide mouthed vials in a small covered tin kettle, which may be carried by hand or in a carriage, without corking the bottles, and without the risk of losing any of the water; this plan is preferable to stopping the bottles, on account of its not endangering the lives of any delicate animalcules that may be present, especially if some time will elapse after their collection before the bottles can be attended to at home.

It will also be necessary to have a long rod or stick to one end of which a bottle, or a small fine *muslin net* may be fastened by

a piece of twine, or otherwise. Having arrived at the place where the collection is to be made, the bottle attached to one end of the rod and held in an inverted position, must be brought as closely as possible to the masses of diatoms in the water, passed slowly down into the water a short distance, and then turned upward, as it is inclined upward the water will enter it carrying the diatomaceæ along. Or, if the diatoms are at the bottom of the water, the bottle may be carried horizontally along the bottom, and thus many of them be secured; some persons use a spoon to detach them from the bottom; and when they are entangled in the meshes of their stems, they may be cut off by means of a knife made in the shape of a pruning hook.

Frequently, the *muslin net* will be found preferable to the bottle, as it will collect many specimens without a superfluity of water, as it allows this fluid to drain off; this will answer, especially, where the diatoms float upon the surface of the water.

There will frequently be considerable mud, sand or other foreign matter with the collection, but by exposing the bottles for some time to the light of the sun, the diatoms will collect on the surface and may be removed with a dipping tube. Or, by agitating the water and diffusing the particles through it, the coarser and heavy particles will speedily subside on allowing the bottle to rest, and the supernatant water may be poured off; and by carefully repeating the process a few times, most of the impurities which would interfere with observation, may be thus removed. The deep sea species may be obtained by dredging, or, by treating the alimentary canal of fishes, mollusks, etc., with strong nitric acid, as now to be described.

When it is desired to prepare the valves for mounting, the best method is to allow the diatoms to settle in the water, then pour all this fluid off, add strong nitric acid to the remaining deposit, and boil for some time, in order to deprive the mass of all organic matters; taking care to remove a portion from time to time with a dipping tube in order to ascertain when the valves are perfectly clean. As soon as this is the case, add twice the amount of distilled water to the acid solution, and allow the whole to settle. Then carefully pour off the supernatant fluid, add more water, and continue this process until all the acid has been washed out, and until a drop of the liquid when evaporated on a slide, leaves no film at the margins of the drop. If the valve be not perfectly

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cleansed in this manner, the specimen will be spoiled after mounting it. The diatoms or valves thus thoroughly washed, may be kept in alcohol in readiness for mounting.

Those who do not live near the sea-shore, may obtain many beautiful diatoms from the oyster juice contained in the oyster cans sent to various inland sections of the country, by the following process:—Pour the juice into a tall glass jar or bottle, and when there is no further deposit of sediment, pour off the supernatant liquor, and supply its place with clear water; as soon as no more deposit occurs, pour off the supernatant fluid as before, supplying its place again with clear water, and repeat this washing process for three or four times. Then, boil the sediment obtained from the last washing in pure sulphuric acid for some time, until all organic matter present is charred; add water to the mixture, let it stand about six hours, and pour off the supernatant fluid. The sediment is now to be again boiled in sulphuric acid, with the addition of chlorate of potassa, according to Prof. J. W. Bailey's method, explained on page 88; finally it must be repeatedly washed with water to remove the acid, and the specimens obtained should be kept in clean alcohol. By this process, I have frequently obtained many fine specimens of *Coscinodiscus*, *Triceratium*, *Grammatophora*, *Heliopelta*, *Cocconeis*, *Gallionella*, *Actinocyclus*, *Campylodiscus*, *Gyrosigma*, *Navicula*, *Sponge Spicules*, etc., etc.

The diatoms may be mounted dry, or in balsam, water, or dilute spirit, (one part of alcohol to six of water). If it be desired to exhibit their delicate markings they should be mounted dry, and placed upon and covered by the thinnest glass which can be obtained. In order to isolate them, or remove them upon the slides, the mounted shaving brush bristle, page 67, will be found very useful, together with a pocket or other lens sufficiently powerful to enable the eye to recognize and select them.

Dr. A. S. Donkin, obtained many beautiful living specimens of marine diatomaceæ, by collecting the sands of still bays, on the shore, where the diatoms are exposed by the reflux of the tide, at a distance corresponding with the half-tide margin. In these places, where the sands are sloping toward the sea, and grooved out into small furrows, filled with salt water oozing out from behind, the living diatoms imparted to the surface of the sand different hues of chesnut and olive, according to the species

present. During the sunshine, these colored patches were studded by numerous minute air-bubbles. As he could not separate them from the sand, he carefully scooped up the surface of the colored sand, emptied it into a wide mouthed bottle, and when half full, filled the other half with salt water. He then shook the whole briskly, and allowed the bottle to stand for a short time; the sand fell to the bottom, the diatoms remained suspended in the water above, forming about the $\frac{1}{1000}$th part of the whole. These were removed into another bottle, the sand thrown away, and by not having a superfluous amount of salt water, he was enabled to convey them home in ounce and a half vials.

The DESMIDIACEÆ, consist entirely of microscopic flexible confervoid algæ, and are found inhabiting fresh waters, resting at the bottom of the water, adhering to aquatic plants, or lying in exposed situations, etc. The peculiarity, beauty, and variety of their forms, and their external marking and appendages, render them very interesting objects of microscopic investigation. They are of a green color, evolve oxygen when exposed to the light of the sun, and some have the power of attaching themselves to external objects, while others possess feeble powers of locomotion.

Their modes of reproduction are; 1, by cell division where each frustule divides into two; 2, by the discharge of active ciliated zoospores from the parent-cells, which after a time, arrange themselves within the sac containing them, forming a colony having the regular pattern of the species, and in which each zoospore becomes one of the notched frustules of the group; 3, by a process analogous to the preceding, but in which no motion takes place; cellulose coverings are acquired, the zoospores arrange themselves within the parent cell, which ultimately splits, peels off, and leaves them as the foundation of a new group; 4, by conjugation, where two parent cells unite to form a spore.

The desmidiæ may be collected in the same manner as recommended for the diatoms. They are rather difficult to preserve, being more or less altered by the preservative liquids; Thwaite's liquid, Ralf's liquid, and camphor water, probably, produce the least change. A few of them are not changed by chloride of calcium. They are not to be found in turbid waters, but more generally in those which are always clear to the very bottom.

INFUSORIA may be collected in the same manner as the preced-

ing objects, and placed upon slides according to the method named under *pipettes* or *dipping tubes*. If viewed by the low powers they need not be covered by thin glass; but they must be covered when the high powers are used, both for the purpose of flattening the drop, and rendering it sufficiently shallow to allow of the animalcule being brought within the focus of the objective, and likewise to prevent the object glass from becoming soiled or injured by the contact with water; a minute portion of dirt in the drop will prevent the thin cover from crushing these living specks. The animalcule cage is best adapted to the examination of infusoria with the higher powers. But in the absence of this, I have found a thin glass cover, having a narrow slip of very thin glass cemented on each end by Canada balsam, quite useful in preventing many forms of animalcules from being crushed, the cemented slips preventing the thin cover from resting its whole weight upon their delicate bodies.

The bodies of infusoria are composed of protein compounds, and are soluble in solution of potash. The simplest form consists of a glutinous, homogeneous or slightly granular diaphanous mass of sarcode, in which no trace of organs can be detected. And from this they proceed upward until they assume a more complex form, having many distinct and mostly transparent organs, as well as an apparent circulation. By rubbing up some carmine or indigo with water, and placing a drop of it on the slide containing the animalcules, they will feed upon it, and thus enable the observer to detect their stomachs by the coloration effected thereby.

The red pigment of a fly's eye, obtained by rubbing up the fly's head with a drop or two of water, has been recommended for the same purpose, and is said to be superior to the above, the animalcules greedily devouring it, beside which it does not crowd the field of view with dark particles, embarrassing the eye and confusing the object, as is the case with carmine and indigo.

They propagate, in many instances, similar to the desmidiæ, as, by spontaneous division in which the body of one divides transversely or horizontally into two perfect animals; by *gemmation;* by diffluence, where the substance of the body breaks up into a number of pieces, each of which becomes a [illegible] individual, though some doubt this process; by e[illegible] which the animal becomes rounded, and enclosed in [illegible]

matter, and the encysted mass is then converted into a variable number of new individuals discharged by the bursting of the parent cyst; by *conjugation;* and by actual sexual intercourse, deposit of eggs, etc.

Infusoria are met with in all kinds of water, except that which is pure, as spring water. They may be seen in a drop of water placed on a slide covered with thin glass, but their natural movements are best observed in the animalcule cage; sometimes the thin glass cover prepared as named on page 84, may be advantageously used to observe their motions, and when it is desired to arrest their motions, it may be effected by warming the slide containing them over a lamp or a candle for a short time. They are very difficult to preserve; some exhibit the cilia, vacuoles, etc., very well when dried; others are but little changed by a concentrated solution of chloride of lime, or by a solution of chromic acid; and several keep very well in Deane's Gelatine; but the greater part of them can only be observed during their life time.

By Fossil Infusoria is meant the fossil valves of the Diatomaceæ, and which are found in vast numbers in aquatic and marine geological deposits, forming hills, rocks, and various strata; also in peat-beds, guano, tripoli, various infusorial earths, as they are called, as those of Richmond, Va., Bermuda, Petersburg, Va. Andover, Conn., etc. Several plans have been recommended to prepare these fossil diatoms for mounting and microscopic examination, a few of which I will select.

Beale recommends calcination as being less liable to break the shells, than when the deposit containing them is boiled for some time in strong acid; he says: "I much prefer to destroy the organic matter by burning the deposit in a platinum basin, and allowing it to remain for some hours at a red heat until the black carbonaceous matter has burnt off, leaving a pure white ash. From which the phosphates and carbonates may be removed with dilute nitric acid, and the remaining deposit be then washed for mounting."

Quekett says: "A great many of the infusorial earths may be mounted as objects without any previous washing or preparation;
[illegible] chalk, must be repeatedly washed, to
[illegible] impurities; while others, by far the
[illegible] ire either to be digested for a long

time, or even boiled in strong nitric, or hydrochloric acid, for the same purpose. Place a small portion of the earth to be prepared, in a test tube or other convenient vessel capable of bearing the heat of a lamp; then pour upon it enough diluted hydrochloric acid to about half fill the tube. Brisk effervescence will now take place, which may be assisted by the application of a small amount of heat, either from a sand-bath or from a lamp; as soon as the action of this acid has ceased, another supply may be added; and the same continued until no further effect is produced.

"Strong nitric acid should now be substituted for the hydrochloric, when a further effervescence will take place, which may be greatly aided by heat; after two or three fresh supplies of this acid, distilled water may be employed to neutralize all remains of acid in the tube; and this should be repeated until the water comes away perfectly clear, and without any trace of acidity. The residuum of the earth, which consists of silica, will contain all the infusorial forms," (which instead of being kept in a vial in the dry state, should be kept in alcohol, to keep them from cohering together, K.); "and some of this may be taken up by a pipette, dipping tube, or mounted bristle, laid on a slide, and examined in the usual manner.

"Should perfect specimens of the Coscinodiscus, Gallionella, or Navicula, etc., be present, they may be isolated with the mounted bristle, if required, and mounted in Canada Balsam; if not, the slide may be wiped clean," (by first dipping it two or three times in water, and then drying with a soft piece of old muslin, which will thus prevent the silica from scratching it, K.) "and another portion of the sediment taken, and dealt with in the same way; or, if good, after being dried it may be mounted in Canada Balsam." By keeping the fossil infusoria in alcohol instead of water, they dry much more rapidly when placed upon a slide.

The fossils of many earths, as for instance, of the Richmond earth, may often be more easily obtained than by the method just named, thus,—place a small portion of the earth in a wine-glass of water, stir it and give to it a strong rotary motion for ten or twenty seconds—the fossils will be deposited upon the sides of the glass. If I am not mistaken, this plan of procuring fossil diatoms originated with the late Prof. J. W. Bailey.

Guano contains a large amount of animal matter, and requires

a somewhat different mode of treatment. Mr. Henry Deane, of Clapham, England, recommends the following method:—"Take a convenient quantity of guano, and wash it several times in distilled water, until the water is no longer colored by it, observing, to stir it well after each addition of water, and then allow the sediment to settle for some hours, that none of the lighter diatoms may be lost, which might be the case were the water poured off too soon.

"When sufficiently washed, place the sediment in a test-tube, or flask, and add some hydrochloric acid to it; when effervescence ceases, subject the mixture to a gentle heat, continuing it as long as effervescence continues. When this again ceases, allow the mixture to stand until the sediment has all subsided, pour off the clear acid, and add another portion; repeating this process as long as the acid produces effervescence.

"When hydrochloric acid no longer occasions effervescence, a quantity of strong nitric acid, say two fluid ounces to every ounce of guano, should be added in place of the hydrochloric; this occasions a strong effervescence, upon the cessation of which the mixture should be exposed to a continued heat of 200° F., for six hours, during which time the greater part of the guano is dissolved.

"The mixture is then allowed to stand in a cold place for twenty-four hours, in which time all the sediment will have settled; the clear acid liquor must be poured off, and a fresh quantity of strong nitric acid added, repeating this until no further effervescence ensues.

"The sediment is, finally, to be repeatedly washed in distilled water, until no trace of acid remains; being careful after each washing, not to pour off the water, until sufficient time has elapsed for all the sediment to subside. And should no siliceous sand be in the guano, the washed deposit will be found to consist of diatoms, etc."

Should the deposit contain sand, it may be separated from them, and the diatoms also be procured, the coarser and finer kinds by themselves, by the following process of Okeden. Place the diatoms in a tall narrow glass vessel nearly filled with water and stir it quickly; as soon as the coarser po ... ided, which will be long before the motion of ... off the supernatant water, and set it asid ... may be treated three or four times ... e

diatoms have been removed from the sand, which may be thrown away. Now, after the sediment in the decanted portions of water which have been set aside, have subsided, treat it in the same way as before, allowing about a minute to pass after stirring, when the supernatant fluid may be poured off, and the sediment will be found to consist of the coarser diatoms.

Take the sediment of the second decanted portions of water, and treat it in the same manner, as before, allowing two and a half minutes to pass after stirring, when a still finer supply of diatoms will be procured. And the process may be repeated several times, each time allowing a longer period for the sediment to subside, as the finer diatoms float in the water much longer than the coarser ones, requiring half an hour, or even two or three hours before they will be deposited on the bottom of the vessel.

When there is much sand with the diatoms, I have found it a very quick method to make a saturated solution of salt, in a portion of which the mass is to be agitated, and then allowed to stand; the sand is deposited more quickly than the diatoms. In a minute or so pour off the fluid into another tall glass jar, and again agitate the sand in more of the salt solution, repeating the process three or four times. Mix the solutions together, containing the diatoms, and when all have been deposited, pour off the supernatant liquid, and remove the salt from the diatoms by washing them in pure water, several times.

The late Prof. J. W. Bailey of West Point, N. Y., stated to me the following method which he pursued when infusorial matters were mixed with other organic bodies:—"All the lime present is to be dissolved out by nitric acid, filter, then with a little water wash the contents of the filter into a porcelain capsule, to which add strong sulphuric acid, and apply heat until the extraneous matters are all charred. Then while the capsule is still over the lamp, and the acid is VERY HOT, drop in *carefully*, a very small quantity at a time of powdered chlorate of potassa, continuing its addition until the acid is clear, or of a light yellow or reddish color. This oxidizes the carbon, and if the acid is *hot enough* there is no accumulation of the explosive compounds of chlorine. The resulting sediment is beautifully white and clear; it must then be washed with water and cleansed of acid by decantation as above, repeating the washing three or four times. I never

dry the sediment as when once felted together it does not break up well; I add alcohol and keep it in the liquid state."

Should any sand be mixed up with the infusorial specimens, these may be isolated from it by one of the modes above recommended. The various processes referred to, of boiling with sulphuric acid, nitric acid, etc., should not be conducted in the apartment where the microscope is kept, lest the glasses become injured thereby from the action of the gaseous matter evolved, upon them. In powdering the chlorate of potassa, it may be placed in a glass or Wedgewood mortar, covered with considerable water, and rubbed with the pestle; if no water be added, a dangerous explosion will be apt to take place during the trituration. After it has been sufficiently powdered, filter, dry the salt on the filter, and carefully remove into a labelled vial.

Fossil diatoms are often so firmly consolidated together, that it proves very difficult, if not entirely impossible, to separate or disperse them, in either cold or boiling alcohol or water; maceration in acids; frequent exposures to intense cold and heat, alternately, etc. And if it be attempted to separate them by crushing the cemented mass, or by scraping or filing, the finest specimens are destroyed. The material which thus holds the diatoms together, is usually of a siliceous character, and may be destroyed by the following means: Pieces of the agglutinated diatoms are placed into a suitable vessel, as for instance, a test-tube, then covered with a strong alkaline solution, and exposed to the flame of an alcohol lamp; as soon as the pieces are observed to fall to a powder, they must be *immediately* emptied into a vessel containing twenty or thirty times as much water as there is of the alkaline ley, in order to prevent the caustic solution from acting upon the diatoms also; and which water may be poured off, after the diatoms have all been deposited. The alkaline solution may be made of either caustic soda or potash. Some specimens will give way to a weak solution, while others will require one very strong; the better plan will be to commence with a weak liquor, and increase its strength as often as it is observed that a boiling temperature continued for a few minutes does not cause the agglutinated mass to crumble. If the operator waits until the whole mass is reduced to powder by this [illegible] that the greater part of the diatoms will be [illegible] he must empty the whole in water, as ab[illegible]

perceives the mass breaking up, repeating the action of the alkaline solution on the untouched lumps, as often as may be necessary:—and if the alkaline liquor appears to act too powerfully on the masses, it should be diluted. Sometimes, the cementing material will be so hard and stony, that the diatoms will be dissolved before the masses can be acted upon sufficiently to crumble. After the whole mass has thus been reduced to powder, the diatoms should be repeatedly washed in clean cold water, until every trace of alkali has been removed; and then, if required they may be boiled in acid, with or without the chlorate of potash, and prepared for mounting, as heretofore named on page 82, *Prof. J. W. Bailey.*

"*Foraminifera* may be separated by taking the sediment or earth in which they are supposed to exist, and gradually, but thoroughly drying it; then take a glass full of cold water and strew the powder upon the surface of the water, when, in a few minutes, the earth and sand will sink to the bottom of the glass, and the shells, being filled with air, will float upon the surface, and may be removed by gently introducing a glass slide under them."—*Pritchard.*

In procuring *fossil specimens from chalk*, rub the chalk to powder with water, by means of a soft brush; and separate the specimens according to the plan named above by Okeden. Or, a piece of chalk may be finely scraped upon a glass slide, a drop of water be added to it, and after remaining for a few seconds, the water, with any particles floating on it, should be removed; and the sediment left on the glass should be dried and mounted in balsam.

According to Quekett, Dr. Southby recommends to boil the piece of chalk in a saturated solution of sulphate of soda; the subsequent crystalization of the sulphate, tears the chalk to atoms without injuring the shells.

In the examination of *coal*, it should "be macerated for about a week in a solution of carbonate of potash; at the end of that time, it is possible to cut tolerably thin slices with a razor. These slices are then to be placed in a watch-glass with strong nitric acid, covered, and gently heated; they soon turn brownish, then yellow, when the process must be arrested by dropping the whole into a saucer of cold water, or else the coal would be dissolved. The slices thus treated appear of a darkish amber color; very

transparent, and exhibit the structure, when existing, most clearly. The specimens are best preserved in glycerin, in cells."—*Mic. Dict.*

In relation to the preparation of other objects for mounting, a few general remarks may be offered, for which I am indebted to the Microscopic Dictionary. "The soft parts of animal or vegetable bodies are separated by means of needles under a dissecting microscope, or by means of sections, according to the nature of the views which it is desired to obtain. The separation by needles is usually performed under water, in a watch glass, cell, or other convenient holder.

"The preparation of sections is a more complicated process. *Soft parts of animals* are best sliced by means of a Valentine's knife; but *horn*, and other firmer structures, may be cut with a sharp razor. *Vegetable structures* in general are sliced with a razor, which must be kept very sharp, and rubbed on a strop frequently while in use, and always before putting it away.

"*Fresh stems*, *thick leaves*, etc., may be simply held in the fingers; thin objects, such as *leaves*, *petals*, etc., are best placed in a split cork, the halves of which are kept together by insertion in the neck of a vial, or a test-tube, which at the same time serves as a handle. In cutting the section the razor is carried through the cork, from which the object must be subsequently separated. Sometimes it is advantageous to immerse objects, especially soft or very small ones, in thick mucilage of gum arabic, and to allow this to dry until tough enough to be cut by the razor; the slices are afterward freed from the gum by immersion in water.

"*Dry objects*, such as *wood*, *dried leaves*, *seeds*, etc., must be softened by soaking in water before slicing. Small firm objects, such as seeds, are most easily sliced when fixed in a bit of white wax or stearin, which may be done by placing them on the surface of the latter, and stirring them into the substance melted by the application of a hot wire. Most slices of vegetable objects are obscured by air-bubbles engaged in the intercellular passages, etc. In old wood and similar objects the air is readily driven out by heat; in fresh structures, where heat may coagulate or dissolve matters, the air may be allowed to dissolve or escape by itself, which requires time, or may be removed by exhaustion.

"A substitute for a regular air-pump may prove us[illegible] microscopist, consisting of a piece of thick and sto[illegible]

closed at one end, containing a tight fitting piston, with a valve opening upward; the object being placed in water (or other liquid) at the bottom, a single raising of the piston, or at all events two pulls will draw out all the air, and the water will take its place as the piston is lowered. This apparatus may be used also for saturating dry objects with oil of turpentine (for mounting in balsam), or with oil to produce transparency.

" *Sections of wood*, etc., which are to be mounted in liquids, should be soaked for some little time in spirit or turpentine, to remove resinous matter, etc. A special apparatus is made for slicing such objects, but this is not of much use except when large numbers of very perfect sections of the same kind are required for purposes of sale, etc. A brass tube about an inch in length, and half an inch in diameter, closed at one end, with a screw and milled head passing through the closed end, so as to move a circular diaphram up or down within the tube, will be found an excellent section cutter for many purposes; using a razor to cut the slices. When the object is too small to fill the diameter of the tube, it may be placed between two pieces of cork, and the whole be sliced together; afterward removing the object from the cork. Sections require to be made in various directions, in order to properly study an object. Thus *stems* should be sliced horizontally, and perpendicularly, both parallel to the medullary rays, and at right angles to them, etc.

"The structure of *laminated shells*, etc., may often be seen in fragments broken off by the point of a knife. But *sections of shell*, *bone*, etc., are best made by sawing off as thin pieces as possible, with a frame saw having a watch-spring blade, grinding them down upon a water-of-Ayr, Arkansas, or some other stone, and polishing them upon a clean leather-hone or strop with putty powder and water, and finally upon a dry hone alone. This process may be much facilitated by polishing one side of the object previous to sawing it, and then after the section is made, fastening the polished side to a level surface of cork, by means of shell-lac, sealing wax, or glue, etc., by which a handle is afforded to work by; and after the section is reduced to a sufficient thinness and polish, it may be removed from the cork, by some appropriate fluid.

" Sections of very hard substances, as *agate*, etc., are so easily made by jewellers, that a description of the process is scarcely

necessary. They are made by means of a circular iron plate, made to rotate by a lathe, its margins being coated with a mixture of oil and diamond dust. They are then ground upon a plate of metal with emery powder and water, and polished upon a flat surface of pitch, with putty powder and water.

"In grinding and polishing sections of hard structures, it is often requisite to cement them to a slide with Canada balsam, heat being applied until the balsam has become so hard as to fix the section firmly to the slide. As soon as one side has been polished, the section is removed from the slide, the balsam being rendered soft by heat, the polished side cemented to the glass, and the other side polished. The balsam may afterward be removed from the section by maceration in oil of turpentine, ether, etc."—*Mic. Dict.*

CHAPTER VI.

MOUNTING AND PRESERVATION OF OBJECTS.

"*Soluble crystals* are preserved with difficulty, and the more soluble crystals of an organic nature can seldom be preserved unless they are perfectly pure. Crystals of chloride of sodium keep pretty well in their mother-liquor, as well as other crystals which contain water of crystallization; oxalate of lime may be preserved in an aqueous solution containing a little oxalic acid; triple-phosphate, in water containing an ammoniacal salt in solution, or, in water to which a little aqua ammonia and muriate of ammonia have been added, which preserves the beautiful smooth character of their surfaces; dumb-bells (oxalurate of lime,) in *Deane's gelatine;* cystine, in a dilute solution of acetic acid; epithelium may be preserved in Deane's gelatine, creosote, or naphtha solution. And whatever preservative fluid is used, care should be taken that the deposit to be put up is thoroughly saturated with it, for unless this object be attained, there is danger of the preparation being destroyed after a time. Uric acid may be mounted dry, in preservative fluid, or in Canada balsam; when crystals are put up as objects for examination with polarized light, they should be mounted in Canada balsam, or oil of turpentine. Insoluble crystals may be mounted dry, in Canada balsam, or in some aqueous solution."—*Beale.*

Transparent objects are usually mounted in a way which will display their minute structure to the greatest advantage; thus, some are mounted in a dry state, some in cells in some preservative liquid, and others again in Canada balsam, oil, turpentine, or some highly refracting medium. The glass slides used, as well as the thin glass covers, should be clear, and free from veins and bubbles. Delicate animal and vegetable tissues, exhibit their structure more clearly when mounted in some preservative fluid.

In mounting in the DRY WAY, if the object be extremely thin, it may simply be placed on a glass slide, covered with thin glass,

which should be kept in its place by pasting with gum a piece of paper rather larger than the thin glass cover, in the center of which a hole has been cut of less size than the cover, but sufficiently large to permit the entire object being seen ; or the cover may be fastened to the slide by touching its edges with sealing wax, varnish, or other suitable cement.

If gum-paste and paper is used in fastening the cover, this should be gently pressed and held down, and the paste be dried as quickly as possible, in order to prevent any of it from being drawn by capillary attraction between the cover and the slide, and thus by reaching the object, spoil it.

If the object is rather thick, a paper or pasteboard cell or a thin glass cell may be fastened to the slide, within which the object is placed, and over the whole of which the thin glass cover is cemented. If it be desired to examine the object by reflected light, as an *opaque body*, it should be placed upon a dark ground, as blackened pasteboard, or in a pill box, or, the glass slide on which it is mounted, may have a piece of black paper, some black paint, or black varnish applied to the side opposite to the one on which the object is placed.

The objects which are best mounted in the dry state, are test objects from infusoria, scales of butterflies and other insects, hairs of animals, sections of some kinds of wood, also of bone, and teeth.

When objects are to be mounted in CANADA BALSAM, they should be thoroughly dried and freed from moisture, otherwise they will acquire a milky appearance from being surrounded by minute drops of water. To prevent the objects from becoming curled up, or deformed while drying, they may be held between two glass slides. They may be dried in the sun, by means of a gentle heat, or, if this would injure their structure, they may be thoroughly dried by exposing the slide holding them for some time over a dish containing strong sulphuric acid, the whole being covered with a bell jar, or placed under a receiver, which may be exhausted by connecting it with the air-pump.

Some objects, as parts of insects, must be soaked for some time in oil of turpentine, which removes the air from their interstices, and renders them more transparent. Any [illegible] or greasy matter may be removed from the object by [illegible] iects are very thin and transparent, so as to [illegible]

in the balsam, they should be darkened either by charring them over a lamp between two plates of glass, or by soaking them in a weak solution of iodine, or a decoction of logwood. For mounting, pale Canada balsam, not too old, is the best for ordinary use, and it should be kept in a clean, wide-mouthed, covered vial.

Many persons place the body of a small insect, or one of its limbs, under a microscope, and instead of seeing a transparent object, have a dark, opaque substance presented of a very unsatisfactory character. This is because it has not been prepared as a transparent object, by removing its fat or other internal tissue. All organic substances not originally transparent, have to undergo a certain preparation in order to render them so. Thus, the various parts of a bug, or bee, etc., as the limbs, antennæ, eyes, etc., must be soaked in turpentine for a short time, which removes the opaque internal matters; in some instances where there is a hard skin, as with the head of any kind of bee, wasp, cricket, beetle, etc., a maceration in a solution of caustic potash, from five to fifteen days will be required to soften the hard parts and dissolve the internal matter—after which the object should be placed in a watch-glass and washed with water, until it is freed from the alkali, dried by compression between two slides, then macerated for two or three days in spirits of turpentine, and mounted in Canada balsam. To see vegetable cells, as of leaves, flowers, roots, etc., these require to be kept in water until decomposition commences, when the cells may readily be seen. Some cells, and other parts of plants may be seen without such preparation. Pollen should be examined while fresh, a drop of oil of lemon, or of water, will render it transparent. Spores of fungous plants may frequently be seen to pass from out of their spore-cases, by first macerating the cell or case for a short time in a drop or two of alcohol, and then adding a drop of nitric acid; if the slide be now gently heated, and the thin glass be placed over the spore-case, (which must be brought into focus under the objective), a slight degree of pressure will effect the desired object. Some small insects, as the flea, require maceration in spirits of turpentine, before being mounted in balsam. Sea weed, (algæ) may be mounted in balsam; but to observe their propagation, they should be mounted in cells with Goadby's solution, A. No. 2.

The structure of hair may be seen after they have been macerated in a solution of soda or acetic acid, then washed with water,

dried and mounted. And in this way, must all opaque organic substances be prepared previous to mounting; some parts, as bones, etc., require only to be made in thin sections, but most of them require some solvent to remove their opaque substances in order to render them transparent and display their structure.

When the object is properly prepared, being freed from moisture, and air, it may be placed upon the center of a clean slide. A drop of balsam is now taken up on the end of a small wire or knitting needle, the wire is held for a second or two in the flame of an alcohol lamp, being heated near the balsam but not so close as to ignite it; remove the wire quickly from the lamp and hold it over the object, upon which the balsam will directly fall. A little practice will soon make known the length of time during which the wire should be held in the flame, and the rapidity with which the drop of balsam should be conveyed toward and over the object. The slide is now to be warmed over a spirit lamp, or it may be laid upon a warm plate of tin or brass, but must not be heated too much, and any air bubbles which may be present, and which usually ascend to the top of the balsam may be carefully carried to one side and removed from the neighborhood of the object, by means of a small needle, mounted.

This being done, and while the slide and balsam are still warm, the thin glass cover previously cleaned, is to be gently warmed (by carrying it quickly across the flame three or four times,) and then carefully laid upon the surface of the balsam. A small pair of wooden forceps may answer to hold the slide, in warming it, and the ordinary small brass forceps will answer for warming and holding the cover. The simple pressure of the glass cover will cause the superfluous balsam to escape at its sides, and this should be facilitated by a gentle pressure upon the cover. The preparation is now allowed to cool, and as soon as the balsam is perfectly hard, the superfluous portions about the edges of the cover, may be scraped or cut away with a knife, and the surface of the glasses thoroughly cleansed from any remaining balsam by carefully rubbing them with a rag moistened with oil of turpentine, alcohol, or ether. The mounting now being finished, the edges of the cover may be painted with some sealing wax, varnish, or other cement.

Some recommend to drop the balsam on the slide, warm it, and

then place the object upon it; others advise to drop the balsam near the object on the slide, and when it is warmed, allow it to run upon the object. These plans may sometimes be useful, but ordinarily I prefer the method explained.

If the object has been thoroughly dried, and all air removed from its interstices by previously placing it in turpentine, or under the receiver of an air pump, it will thus be well mounted. If too much heat is applied in warming the balsam, so as to render it more fluid, the object will curl up, or be otherwise injured, and a new operation with a new specimen will have to be undertaken. If air bubbles have found their way into the object, the slide will have to be macerated in alcohol, ether, or oil of turpentine, to dissolve the balsam and liberate the object, and a fresh mounting made.

Sometimes, by gently heating the slide sufficiently to render the balsam fluid, the air-bubbles may be removed by moderate pressure upon the cover aided by moving it slightly about, or from side to side; but this will also remove the object from the center of the slide toward one of the edges of the cover, but which is of no importance, if air-bubbles and other obstacles to a correct view of it, are absent. Some preparations require boiling in the balsam, in order to expel the air contained in their internal cavities.

If the object be large, it must be placed in a cell of suitable size attached to the slide by marine glue, the cavity of which cell is to be filled with fluid balsam, and then the cover applied; being careful to remove all air-bubbles before fastening on the cover.

If the object be very minute, it may be placed on the slide, a drop or two of turpentine added to remove the air in its cavities, and the turpentine may be drained off, or allowed to dry by time, or by the application of heat, according to the nature of the object, and the balsam and cover may then be applied as already described.

The objects which are generally mounted in Canada balsam are pollen grains, entire insects, corals, sections of wood, of shells, and of hard fruit envelopes, membranes and thin sections of tissues as of the spinal cord, muscular fiber, etc., diatoms, chalk with foraminifera, parts of insects, polypidoms of zoophytes, fossil infusoria, foraminifera, some crystals, etc.

When objects are to be mounted in media containing *gelatine*, as *Deane's Gelatine*, the same rules will be applicable as for mounting in balsam; the great difficulty consists in getting rid of the air bubbles. The best plan is to warm the slide, place the object on it, cover it with the gelatine warmed and in a fluid state, and then cover with the thin glass previously warmed. If a small portion of the gelatine mixture be previously heated in a watch glass, or small cell, the air-bubbles may be removed before applying the cover.

When objects are MOUNTED IN FLUID OR IN PRESERVATIVE LIQUIDS, cells of various kinds and sizes are used, according to the nature and size of the objects to be preserved. All very delicate animal and vegetable tissues, are usually mounted in this way, and which exhibits their structure clearly; and "that preservative fluid should always be chosen which exerts least action upon the structure of the object which it is required to preserve. The use of spirit should always be avoided if possible, because, although slowly, yet surely, it will act upon the cement used to close the cell."—*Mic. Dict.*

Glass cells, round, oval, square, etc., and of various depths can be had already prepared at the stores of those who sell microscopes, Jas. W. Queen; McAllister and Brother, Philadelphia; Mr. Pike, New York City; Mr. Jas. Foster, Jr., Cincinnati, etc.; these cells are to be fastened upon the glass slides by means of marine glue. The glue is warmed until it is fluid, one edge of the cell, warmed, is then rubbed with the glue, immediately placed upon the warmed slide, and held there, until cold, by the fingers, or by a weight placed upon it. The superfluous glue is first removed by a warm knife and then by rubbing with a cloth moistened in a solution of potash. The cell is now ready for use. In some instances, thin glass cells are fastened to the slides by Canada balsam, gold size, various varnishes, etc. The surface of glass to which a cement is to be applied should always be roughened by grinding or rubbing on a perfectly flat pewter plate with emery and a little water, as the cement adheres much more intimately to a rough surface than to the polished glass.

A thin glass cell may be made by cementing a square of thin glass to the flat surface of a ring of brass or of glass; the central opening being of the exact size of that required to be made in the thin glass. When the marine glue is cold, a file is forced

through the center of the thin glass, which will not be injured at its cemented part, and the edges must then be filed smooth. A little warmth will remove it from the ring, after which it may be cleaned in a solution of potash, dried, and be fixed upon a slide with cement, to form a thin glass cell.

When an object is to be preserved in fluid it should be allowed to soak for a day or two in some of the fluid, previous to mounting it. The cell is then to be filled with the preservative fluid, the object carefully placed in it by means of a forceps or pipette, and the thin glass cover applied. This cover should be of slightly less diameter than that of the outer margin of the glass cell, and when placed upon it, should be made to slide upon the upper surface of the cell, so as to displace any excess of fluid, and prevent the admission of air-bubbles. The superabundant fluid is then forced out by gentle pressure, and may be removed by a piece of blotting paper, old muslin, or soft sponge. If there is not enough fluid to fill the cell, as indicated by a bubble of air, the cover must be removed, and more liquid be added until a slight excess be present, when replace the cover as before.

After removing the superfluous fluid, allow the edges of the cell and cover to dry for a minute or two, when the thin glass cover may be fixed in its place, by coating it lightly with a thin layer of Brunswick black, gold size, or other of the *liquid cements*, by means of a small camel's hair pencil, or with a small piece of soft wood cut to a blunt point, and hammered in order to separate the fibres a little. When this coat of cement is thoroughly dry, and not before, another layer of cement must be applied, and so continue, until the exposed edges of the thin cover and of the glass cell are firmly cemented together, and the cell so completely closed that no evaporation of the contained fluid can take place. If too large a quantity of cement be laid on at a time, it will be very apt to run into the preparation, or will dry so unevenly as to crack and admit air. When the cementing is perfected, the mounting may be finished by painting the cemented edges with a solution of shell-lac, or sealing wax.

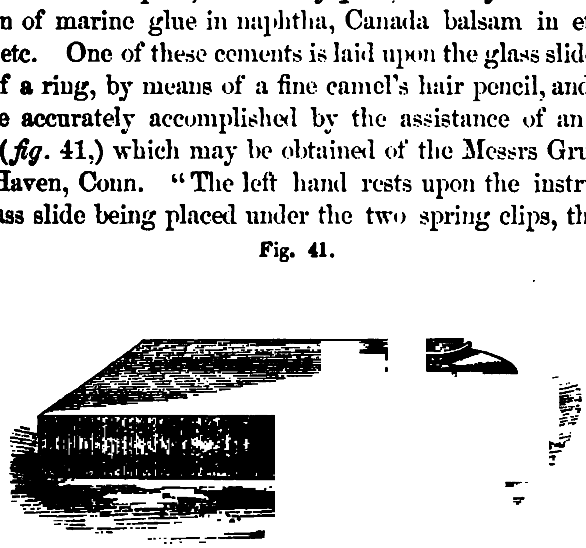
"Specimens are frequently spoiled by the intrusion of the gold-size into the cell; which should not be too fluid, but of the consistence of molasses. Experience will best teach how this accident can be avoided. Attention, however, to the following particulars will assist the inexperienced. The cells should be prepared some

days before they are used, in order that their walls may become firm. The glass slides and thin covers, should be perfectly freed from any grease, and be well cleansed. And when the cell is closed, the brush should be passed round the edge of the cover, with just sufficient size to prevent admission of air into the cell; and upon the operator's care in this respect his success will depend. If too little be used, the air will enter; whereas if too much be put on, or if the cell be not completely filled with fluid, the size will enter, in either case spoiling the specimen."—*Hogg*. To ensure success, it is better to observe that each subsequent layer of cement or varnish be a little broader than the one previously applied.

Large cells are constructed of strips of glass, cemented together by marine glue, and so arranged as to constitute four sides of a box, whose bottom is formed by the glass slide, and top by the thin glass cover.

Cells for minute objects may be made with one of the cements, as, ***gold size*** with which a little finely powdered litharge has been well mixed, and applied immediately, as it soon hardens; or the ***electrical cement*** may be used, provided spirit does not enter into the preservative liquid; or ***black japan***, ***sealing wax varnish***, solution of marine glue in naphtha, Canada balsam in ether, or alone, etc. One of these cements is laid upon the glass slide in the form of a ring, by means of a fine camel's hair pencil, and which may be accurately accomplished by the assistance of an instrument, (***fig.*** 41,) which may be obtained of the Messrs Grunow at New Haven, Conn. "The left hand rests upon the instrument; the glass slide being placed under the two spring clips, the brass

Fig. 41.



circle which works on a pivot by means of the milled head underneath tl volves,

a camel's hair brush dipped in the gold size or other cement, is held in the hand which rests upon the wooden body of the instrument in such a manner that the tip of the brush just touches the glass-slide during its revolution. (The brush should not be too large.) By this means, a thin annular layer of cement is deposited on the slide, which, when dry, serves for a cell. If the cell be not deep enough, a second, and a third, etc., layer of cement may be added when the first has become dry."—*Schaht.*

Some recommend drying the cell by the application of a continued heat until the cement becomes thoroughly hard when cold. The selected preservative fluid is dropped within the cement cell, and the object is placed within it. The edges of the thin glass cover are to be touched with cement, and, in order to avoid air-bubbles arising in the fluid, it should be placed so as to form an angle of about 45° with the glass slide, and then let down very gradually and carefully to its horizontal position upon the cell. Press it lightly, to remove superfluous fluid and also to insure the junction of the cement at its edges with the cement which forms the cell, and then perfect the mounting as named for the glass cell.

Cells are sometimes made of *marine glue*, thus:—melt a little of the glue, and pour it upon a piece of plate glass or pill slab, which has been wetted with cold water, and immediately press upon it another wetted piece of plate glass or pill slab so as to force it into a thin sheet, the amount of thickness depending on the degree of pressure. When cold, separate the plates, if required, by the aid of a large knife, and punch or cut out from the sheet of glue thus made, a number of discs of the necessary size. Heat the slides tolerably hot, and drop one of these discs upon its center, to which it will become attached, and it may be made as hard as desired, by keeping up a gentle warmth for some time. The object is to be mounted and covered as described heretofore.

Coal tar or pitch may also be pressed into thin sheets, and, when dried, be used in the same manner as marine glue for making cells and, for many purposes, sheet india rubber will be found to answer. The cells cut out of these substances will become firmly attached to the glass slides by the application of sufficient heat. I have found a thick solution of *Soluble Glass* to form an excellent and solid cell wall; the cell may be made as shallow or as deep as may be required, and its wall as thick; it may be

applied in the same manner as gold size, by the instrument fig. 41. It may likewise be used to secure the margins of the thin glass cover upon the cell, rendering the cell, in this manner, perfectly and permanently air-tight. It is better adapted for objects preserved in alcohol, as water slowly dissolves it, and ultimately becomes turbid.

According to Thos. S. Ralph, Esq., cells of any form or required size may be made as follows: "Take a slide or piece of glass of the required thickness for the walls of the cell, and place under it a piece of blotting paper folded so as to support the central square inch only, where the hole is to be drilled; have then prepared a steel instrument, called by watch makers a broach, which is a five-sided, well-tempered tool, and sharpen it on a flint or on a hone of some hardness, so as to give it a three or more sided cutting end (this tool should be let into a cedar pencil stick previously deprived of its lead, and glued up again), dipping the point into oil of turpentine, place the end on the glass where the perforation is required, and endeavor to pierce it by a steady drilling movement; the first effect will be to break off a small piece of the surface of the glass, or, if the operator has been too rash, to break it into pieces. Once the surface has been thus scratched, proceed with the drilling, always keeping a drop of turpentine on the spot; in one or two minutes, the drill should penetrate through to the other side of an ordinary glass slide. The finger may be placed behind the spot where the glass generally drops out in a small piece before the point of the instrument. A small hole being thus made, proceed next with a fine rat-tail file, dipped in turpentine, and drill on, and use larger sized files till the opening is of the required size. Two or three minutes will suffice to make a hole of three fourths of an inch in diameter. The operator should *always* begin with a recently sharpened broach; *always* keep it and the files *wet* with turpentine, and in *screwing* the rat-tail file through the glass *always* use it with an *unscrewing* movement, as if you were using a screw driver to *take out* a screw, for the reverse movement immediately *locks* the tool into the glass and a leverage is used, and the glass shivers into pieces; and *never* use the tool with any leverage against the edges of the glass. The required evenness of the edges of the hole may be brought out in five or six minutes, by using a carpenter's *rose* or *counter-sink*, previously sharpened, and *then* hardened in the fire to flint hardn

using this also with turpentine. It is hardly necessary to polish the edges." A square opening can be made in the same manner, with flat files and turpentine, after the orifice has been made sufficiently large to admit the files by the above method.

Mr. Ralph states that a friend has improved on his method, which is much quicker, with less likelihood of breaking the glass. "He prepares a stout plate of brass about the same thickness as the glass, and this plate is perforated with such sized and shaped openings as he wishes to make in the glass. The glass is then cemented to the plate with melted shell-lac or wax, and when cold, a diamond is drawn round the opening in the plate so as to scratch out the size on the glass—this is done chiefly to limit the fracture of the glass. He then perforates the glass, in the manner above described, with the broach, and uses the rat-tail files with the most unsparing vigor, so as to shiver the glass to pieces as far as the marked outline of the cell. This is done in a minute or two, and then, polishing the edges a little, he soaks the glass in a solution of soda, or melts off the cement." A piece of this glass may be cemented on one side of this opening, by means of marine glue or other cement, the object and preservative mixture be placed in the cell thus made, and then covered with another thin glass cover, in the way heretofore named.

As soon as the mounting of an object is finished, its name should be labeled upon one end of the slide, either with a writing diamond, or with a paper label pasted upon it, having its name and other particulars expressed thereon in writing. It is a good plan to number each slide, and enter its number, date of mounting, fluid used, etc., in a book kept for that purpose, and which will not only facilitate the means of finding the slide when required, but also a knowledge of its particulars.—(*see page* 71.)

All microscopical preparations should be kept in boxes or drawers prepared for the purpose, in order to preserve them from dust and from the influence of light. Dry preparations and those mounted in Canada Balsam may be arranged in vertical grooves cut into the partitions of the drawer. The grooves should be wide enough to allow the slide to fall in easily, and should be about a quarter of an inch apart. Preparations mounted in fluid, however, must be kept in a horizontal position, although they necessarily occupy much space; but otherwise it will be found that the tendency for the cells to leak is much increased. Large prepara-

tions can only be kept lying perfectly flat in shallow drawers."—*L. Beale.*

For keeping slides on their edges in grooves made in boxes, a very cheap plan is to fold light pasteboard, alternately in opposite directions, like the folds of a fan. Two strips thus made, being folded evenly and at equal distances may be placed in a box of proper size, and the slides will be held as firmly and as safely in the folds or grooves thus made, as by any other method.

Mr. Deane observes; most objects require to be mounted in some fluid, as very few can be preserved unaltered for any time when dry. Scales of insects, hairs, test-objects, etc., may be mounted dry, and will thus exhibit their lines, etc., more distinctly. In dry mounting a few of the objects are laid upon the glass-slide previously moistened with the breath, in order to make them adhere to it, then cover with a thin glass cover, and paste round both slide and cover a piece of paper, having an opening in its center, corresponding to the size of the thin cover and the position of the object. When animal specimens are desired to be preserved in the dry state, it is better to moisten them with oil of turpentine, which protects them from vegetable and animal parasites, and which, on evaporating, leaves a very delicate varnish-like coating. Sections of wood, fresh vegetables, etc., may be mounted in *Deane's Gelatine;* desmidiæ, diatoms, etc., require it to be reduced with enough distilled water, until its specific gravity is about the same as that of the contents of the cells of the plants, otherwise if it be too dense, they will be spoiled. Powdered objects should first be mixed with a very little water on the glass slide, and then mixed with the *gelatine*, by means of a small pointed instrument, immediately before covering it with the thin glass. Always gently warm the slide and glass cover before allowing the preparation to come in contact with them. When objects are mounted in fluid, great care must be taken in wiping the glass slides not to bend the glass, and thus cause the cell to partially spring from its place and cause a leakage of the fluid; this is very apt to be the case when the slide is held between the finger and thumb in cleaning it.

CHAPTER VII.

OBJECTS OF INTEREST TO THE BEGINNER IN MICROSCOPIC EXAMINATION; THE PLACES IN WHICH INFUSORIA MAY BE FOUND; MICROSCOPIC ANALYSIS.

AMONG the objects which will at first interest the beginner, are the scales of various insects, as of lepisma saccharina, window-fish or small book-worm, of several butterflies, etc., wings of insects; cheese-mites; the animals on figs, raisins, etc., the itch animal; stings, antennæ, feet, eyes, eggs, etc., of insects; hairs of various animals; leaves, seeds, and down on plants; pollen of flowers; mosses; moldiness; circulation of the blood in the foot of the frog; louse, flea; eels in paste, vinegar, etc., very small flies, and insects of all kinds; sections of various woods; ferns; spiracles and trachea of insects; sections of bone; scales of fish; etc., etc. A very beautiful effect may be produced with a scrap of a common fly's eye, dragon's fly eye, or other hexagonal eye, thus—place the body of the microscope in a horizontal position, with the object-glass looking toward the window; place the scrap of eye on the stage, and bring it into focus, so that the hexagons may be seen very distinctly. If now the body of the microscope be gradually moved from the stage, at a certain distance, the hexagons will become dim and confused, but in the center of each will be seen distinctly, small images of the trees, houses, etc., which are in a line with the direction of the microscopic body.

The most popular objects for examination by the *polarizing apparatus* are, starch, tous les mois, arrow root, carbonate of lime, cholesterine, variously colored selenite, crystals of bichromate of potash, chlorate of potash, chromate of potash, uric acid, tartaric acid, malate of lead, sulphate of cadmium, tremolite, zeolite, microcosmic salt, hippuric acid, bi-tartrate of lime, sulphate of nickel, salicine, raphides of onion, and rhubarb, section of echinus, grey human hair, spicules of gorgonia, sulphate of nickel,

triple phosphate, oxalate of soda, nitrate of potash, citric acid, negro skin, white skin, vegetable ivory, hoof of horse, hoof of ox, horn of rhinoceros, horn of ox, scales of lepidoptera, etc.

The examination of animalcules in water is replete with instruction and amusement. All the smaller or ordinary kinds may be found in water in which decomposition of vegetable or animal matter is going on, as for instance, in water in which a few flowers or stems of plants have been allowed to macerate for several days. The first animalcules observed, are usually the monads, mere moving specks or globules; these increase rapidly, disappear, and are followed by larger and more perfect creatures, one generation passing away in a few days, and being supplanted by another of a new species, and thus continuing until cold weather or other causes retards any further increase. They may also be procured from infusions of vegetables, and from fetid ditch water. Ordinary spring water does not contain any animalcules, though rain-water is very apt to give several kinds.

The microscope is the best and most certain test of the purity of drinking water,—for, in proportion to the absence of inorganic and organic matters in a state of decomposition, will the water be free from microscopic plants and animalcules.

To obtain the more highly organized animalcules, which are of greater interest to the observer, it will be necessary to select water from rivers, ponds, lakes, marshes, slowly running streams, and in the small ditches found in brick-yards; the water in canals present many interesting varieties, and many may be found upon the stems of water-plants, on sea-weeds, on rocks by the sea-side, and even in the sea itself.

In collecting infusoria, it is always necessary, among the other articles, to be provided with a good pocket lens, so that each specimen of water may be examined to ascertain if any living bodies are present. These may be seen in the vial into which the water is poured; either by the naked eye or by the lens, or a small quantity may be poured into a small white saucer, and examined by means of the lens; if no animalcules are found, the water may be thrown away, and some more favored spot be tried. A little experience will soon enable the inve [illegible] know the best localities for collections, not only of [illegible] ho of desmidiæ and diatoms.

Among the various animal [illegible] ich I

have found in the waters in the immediate neighborhood of Cincinnati, are the following; monas crepusculum or twilight monad; monas flavicans or yellow monad; monas enchelys or flask shaped monad; uvella glaucoma or glaucous uvella; polytoma uvella or grape polytoma; doxococcus ruber or red revolving monad; chilomonas paramecium, or triangular lip monad; bodo saltans, the leaping tailed-monad; cryptomonas ovata, or egg-shaped loricated monad; lagenella euchlora or green flask-shaped monad; pandorina morum or green berry-like globe animalcule; synura uvella or grape ray-globe animalcule; volvox globator or globe animalcules, red, green, and yellow; bacterium triloculare or three celled jointed wand animalcule; vibrio lineola or the line trembling animalcule; vibrio bacillus or wand-like trembling animalcule; spirochœta plicatilis or worm like twisting animalcule; spirillum undula or wavy cylinder-spiral animalcule; astasia hematodes or blood-like astasia; euglena sanguinea or red eye animalcule; euglena spirogyra or tortuous eye animalcule; euglena triquetra or three sided eye animalcule; amoeba radiosa or radiant amoeba; amoeba guttula; amoeba princeps, or great amoeba; hyalo-theca dissiliens; sphœrozosma vertebratum; cosmarium margaritiferum; arthrodesmus divergens; staurastrum tatracerum; docidium clavatum; closterium acerosum; closterium lunula; closterium setaceum; closterium striolatum; pediastrum heptactis; pediastrum napoleonis; pediastrum boryanum; scenedesmus quadricada; scenedesmus dimorphus? odontella desmidium; odontella filiformis; ceratoneis acus; cocconeis pediculis; cocconeis salina; fragillaria pectinalis; navicula fulva, or yellow navicula; navicula amphisbæna; navicula sigma; navicula amphirhynchus; chœtomonas globulus or globular bristle monad animalcules; stentor Roëselii, or Roesels trumpet animalcule; vorticella convallaria; epistylis plicatilis or folded pillar animalcules; trichodiscus sol, or sun rayed-disc animalcule; leucophrys paluta; coleps elongatus, or long box animalcules; coleps hirtus, or hairy box animalcules; phialina viridis or green bottle animalcules; glaucoma scintillans, or tremulous pearl animalcules; nassula elegans; aspidiscina denticulata or denticulated shield animalcules; paramecium aurelia or slipper animalcule; amphileptus anser, or white, double necked animalcules; amphileptus fasciola; urostyla grandis or great style animalcule; stylonychia lanceolata or lancet armed animalcule; euplotes charon or pearl

skiff-like animalcule; hydatina senta, or large crystal animalcule; pleurotrocha gibba, or awl-shaped tooth rotatoria; notommata myrmeleo or bell-shaped neck-eyed wheel animalcule; polyarthra trigla or narrow many-finned wheel animalcule; euchlanis triquetra or three edged mantle wheel animalcule; brachionus Bakerii or Baker's loricated wheel animalcule; noteus quadricornis; oxytricha gibba, or gibbous hatchet animalcule; chaetonotus larus or gull brushed-fish animalcule; rotifer vulgaris or common wheel animalcule; bell shaped animalcules; polype, or hydra vulgaris; daphnia pulex, or small water flea; cyclops quadricornis or four-horned cyclops; actinophrys sol, or white sun animalcule; pterodina patina or the dish-like winged rotatoria, together with asplanchna Brightwelli, spirogyra quinina, cosmarium tetraophthalmum, closterium moniliferum, scenedesmus obliquus, stentor Mulleri, urocentrum turbo, vorticella nebulifera, hydra viridis, brachionus amphiceros, enteroplea hydatina, cypris tristriata, actinophrys Eichornii, aspidisca denticulata, bursaria vernalis, amblyophis viridis, epistylis grandis, dileptus folium, trachelomonas ——, cyclidium distortum, himantophorus charon, phacus longicauda, and many others; and I have no doubt but that in the waters in the neighborhood of every city, town, or village in the Union, there will be found plenty of microscopic life to interest and instruct.

For a list of works which enter more fully into the various departments of microscopic science, *see preface.* "Pritchard on Infusoria" should be in the hands of every person who wishes to devote his investigations more especially to the microscopic inhabitants of fresh and sea water. For the beginner, "Brocklesby's views of the Microscopic World," and "Wythe's Curiosities of the Microscope" will answer; also a very valuable little work entitled "*The Microscope; being a popular description of the most instructive and beautiful objects for exhibition*,"—by L. Lane Clarke, price 75cts.

In observing microscopic objects, in order to come to a correct conclusion relative thereto, there are several points which should always be carefully att[illegible] and which are as follows:

1. *The shape or form* [illegible] **sary to be correctly determined, and may be** [illegible] **by a low power than a high one. A** [illegible] **ver, cannot be**

arrived at by merely observing one surface of the object,—it should be made to roll over or revolve so that every part of it comes fairly under examination; and this may be effected by immersing the object in alcohol, ether, chloroform, naphtha, or some other volatile liquid in which it is insoluble. The evaporation of these will occasion currents, which will cause the object to turn in every direction so that its true form may be ascertained. Sometimes moving the glass cover sideways, the object being kept in view, or rolling it over with a fine needle or bristle, will be found to answer. When crystalline bodies are found whose chemical compositions are unknown, their angles should be measured with the goniometer.

2. *The color.* The color of objects varies greatly, and often differs, under the microscope, from what was previously conceived regarding them; not only should the color be described, but its cause be accurately determined also. It may originate from partial absorption, the presence of pigment, or other coloring matter, from iridescence, from polarization, etc. Color is often produced, modified, or lost, by the mode of illumination, and by reagents, as, when iodine comes in contact with starch corpuscles, when nitric acid is added to the granules of chlorophylle, or when chlorine water affects the pigment cells of the choroid, etc.

3. *The border or edge*, should be noticed to observe any peculiarities, whether it is so fine as to be scarcely visible, or is dark and abrupt, smooth, irregular, serrated, beaded, ciliated, etc.

4. *The structure of the surface* should be determined, by an examination with reflected and oblique light. Is the surface smooth or rough, are certain lines or marks elevations, depressions, holes, pigment granules, or optical illusions?

5. *The internal structure* of an object, as to its solidity, semi-solidity, homogeneousness; whether it represents a cell, having an outer wall, with contents of a different nature, or is tubular, whether it is composed of an aggregation of similar parts, etc.

"Many textures, especially laminated ones, present a different structure on the surface from that which exists below. If, then, in the demonstration, these have not been separated, the focal point must be changed by means of the fine adjustment. In this way the capillaries in the web of the frog's foot may be seen be covered with an epidermic layer, and the cuticle of some minute fungi or infusoria to possess peculiar markings. Not un

quently the fracture of such structures enables us, on examining the broken edge, to distinguish the difference in structure between the surface and the deeper layers of the tissue under examination." *Bennett.* Both the internal and external structures of objects are frequently rendered distinct by the addition of reagents, and in some cases can alone be distinguished by their use.

6. *Size.* The size of every object, should be accurately ascertained, and, if possible, the size of its tubes, fibers, cells, etc.

7. *Its histological analysis.* "This consists in the resolution of the object into its component morphological elements, and is usually effected by subjecting it to the action of various chemical reagents, continued maceration, etc. It must never be attempted if inorganic matters be present in quantity, until these have been previously removed. The reagent used should be one which exerts a solvent action upon the substance of which the object is composed, the action being interrupted at a certain stage by the addition of water, etc. In regard to those objects whose morphological elements have become altered by individual growth, etc., histological analysis is of course useless; and the manner in which these have acquired their existing structure, can only be determined by tracing the gradual changes which their morphological constituents undergo, from their earliest period of existence to that at which they form the object in question."—*Mic. Dict.*

8. *Transparency.* The transparency of bodies, and of the ultimate elements of many tissues varies considerably; some being quite diaphanous, while others are more or less opaque. The opacity may depend upon inequalities on the external surface, or upon the internal contents. Some opaque bodies which look black by transmitted light, will be found white when seen by reflected light. Other bodies, as oil globules, refract the rays of light strongly, and present a peculiar luminous appearance.

9. *Effects of chemical reagents.* "These are very important in determining the structure and chemical composition of numerous objects and tissues. Thus, water generally causes cell-formations to swell out from endosmosis; while syrup, gum-water, and concentrated saline [illegible] e them to collapse from exosmosis. Acetic [illegible] ated albumen, and renders albuminous [illegible] it operates on cell walls, causing the [illegible] ne so thin as to display their con[illegible] the other hand, and the

alkalies, operate on the fatty compounds, causing their solution and disappearance. The mineral acids dissolve most of the mineral constituents that are met with."—*Bennett.*

In strictly chemical investigations, the employment of the microscope cannot be too highly recommended. In those investigations, where heat is employed, great care must be had not to permit it to warm the lenses of the object-glass, lest the cement with which they are fastened melts or becomes softened so as to allow of their being readily displaced; when this does occur the only remedy is to place them in the hand of the microscope maker that he may re-set them.

The Micrographic Dictionary gives the following concise synopsis of microscopic analysis:—

"*Form:* a, outline; b, rolling over; c, side-view; d, end-view; e, angles, *goniometer.*

"*Color.* 1. General color, true color; 2, pigment; a, partial color from pigment; b, general color from pigment; 3, iridescence, *thin plates;* air-bubbles, etc.; immersion in highly refractive liquids; action of transmitted and reflected light; compression; 4, polarization, etc.

"*Surface.* Reflected light (Brooke's apparatus); projections; cilia, *margin*, *iodine*, *desiccation*, *fine particles;* hairs; crystals, *upon or* beneath the surface; tubercles; ridges; folds, *side view;* effects of altered focus; fracture; foramina, *polariscope;* illusory lines, *diffraction;* depressions, *circular*, *angular;* furrows; tubules; cells; oblique light; stops in condenser.

"*Internal structure and contents.* Solid; semisolid; homogeneous; cell-wall, *endosmosis*, *exosmosis*, *chloride of calcium;* adherence; margin; crushing; molecular motion of contents; granules; nucleus, *central*, *excentric;* reagents, *acetic acid*, etc.; nucleolus; vacuoles.

"*Histological Analysis.* Reagents; maceration; development.

Micro-chemical analysis. Washing; heat; red-heat, *odor*, ash; reagents; contact with reagents, *potash*, *iodine*, *sulphuric*, *muriatic*, *nitric*, *acetic acids;* Millon's test; sulphuric acid and syrup; sulphuric acid and iodine; ether, etc.

"*Measurement.* In fractions of an English inch, (not line nor foreign measures)."

The following objects should be carefully examined that their

characters may be well understood by the microscopist, else, their presence among objects under examination may occasion much difficulty; air-globules, oil-globules milk, bread-crumbs, potato, wheat, and rice starch, worsted, portions of feathers, silk, cotton, and linen fibres, of various colors, hair from blankets, cat's hair dog's hair, human hair, the several parts of flies, fibres of wood swept from the floor, fragments of tea-leaves, hairs from plants, vegetable cellular tissue and spiral vessels, particles of sand, and epithelium from the mouth.

CHAPTER VIII.

MICRO-CHEMISTRY.

Micro-chemical analysis is a very important subject of enquiry, one which cannot be too highly recommended, opening as it does a field of endless investigation of a rich order. Although the quantitative and ultimate analysis of substances cannot be effected in any manner by the aid of microscopic manipulation, yet the qualitative analysis, or the study of the action of chemical reagents upon the object by means of the microscope, may be undertaken with the prospect of almost certain success in most cases, frequently throwing great light upon the distinction of chemical precipitates of closely approximative chemical properties. This branch of microscopic research may be carried on with the ordinary compound microscope, using however, much care, that the chemical agents employed do not injure the object glasses.

On this point, Schaht, in his work on the microscope, and which should be in the hands of every microscopic investigator of the vegetable kingdom, says: "When any chemical reagents are used, whether iodine, caustic potash, or any acid, the object should always be covered with a thin plate of glass; in using volatile acids, such as nitric or hydrochloric, too much care cannot be taken. I avoid using them whenever I possibly can. The vapor of sulphuretted hydrogen has a very injurious effect upon flint glass, which is used by some opticians for the underside of the object-glass. The microscope must be carefully protected against gases of this kind, and even against chlorine and such like gaseous matter, on which account, Schultz's method of boiling the objects with chlorate of potash and nitric acid, must not be undertaken in the room where the microscope is kept."

The best instrument for micro-chemical manipulations, are the inverted or chemical microscopes, (*See page* 46,) in which the object-glass is situated beneath the stage and glass slide, and cannot therefore be injured by the fumes arising from agents used, or, during decomposition of certain tissues; there is, also, no danger

of bringing the objectives in direct contact with corrosive substances, beside which, instead of being confined to the limited space between the slide and object-glass, the operator can manipulate with greater freedom, being enabled with one eye to guide the manipulation on the slide, while the other is occupied almost simultaneously, in looking into the instrument to observe the effects which are ensuing.

Fig. 109

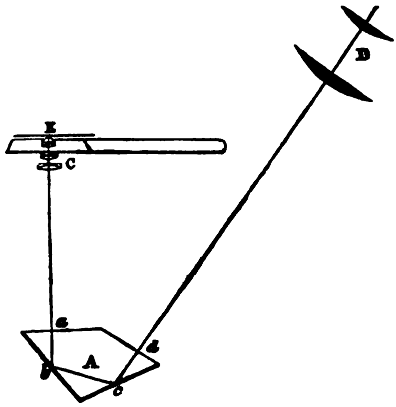


Fig. 109 represents the optical arrangement of the Chemical Microscope, fig. 28. The object is placed upon the stage at E, the object glass C is brought into proper focus, (the light being reflected from above), when the image of the object enters the prism A at *a* and is thrown upon the side *b*, from which it is thrown by total reflection upon the side *c* of the prism; total reflection again occurring, the image is made to pass out at right angles with *d*, and along the compound body, when it is seen by means of the eye-glass D. The Messrs. Grunow are, I believe, the only opticians in this country who manufacture this form of instrument.

The Chevalier pattern of microscope as seen in fig's. 17 and 42, is sometimes used for the chemical examination of fluids, but the same objection exists against it for such investigations, as are found against the ordinary microscope, i. e., the danger to which the object glass is exposed. Fig. 42 represents a superior instrument of this kind, manufactured by Messrs. Grunow & Co., with an indicator stage by which objects once found on a slide, may thereafter be at once placed in the center of the field of view without loss of time, and which, to a microscopist, is a great desideratum.

In all micro-chemical investigations, no matter what kind of microscope is employed, the brass stage should be protected from the action of reagents by means of a large glass slide, or stage of the same size as the brass one; in the chemical

scope it may have an opening made in the center corresponding with that of the brass stage, or, the glass plate may be substituted for the brass one, whenever required. In the ordinary form of microscope, the glass slide and object examined, should invariably

Fig. 42.

be covered with thin glass to protect the objectives, and, in applying corrosive agents, the slide should be removed from the stage, and returned immediately after the addition of the reagent; there is no necessity however, for removing the thin glass cover in doing this, for a drop of any liquid placed upon its edge will at once enter between the slide and thin cover by the power of capillary attraction.

In the chemical microscope a flat thin watch-glass may be used to operate in, or a thin glass cell may be made for the purpose,

thus; take a piece of brass plate about the tenth or sixteenth of an inch thick, and four inches long by one and a half wide, in the center of this perforate a circular hole, half an inch or an inch in diameter; on the periphery of one side of this opening turn out, or make a groove or recess, just deep enough to permit the thin glass to be cemented into it with balsam or marine glue, and so that its surface will be slightly deeper than the surface of the brass, thereby preventing its being scratched when moved on the stage-plate of the microscope. The periphery of the other side of the aperture must be bevelled considerably, which facilitates the cleaning of the cell, and this is the side upon which the manipulations are to be performed. When the thin glass has been fastened to the under part of the slide, in the groove, by melted marine glue, Canada balsam, or marine glue dissolved in naphtha, the circumference of the opposite or operating surface should be coated with two or three layers of asphalte varnish, which will be found an effectual protection against the injurious action of most reagents upon the brass margin.

A variety of reagents are required in this kind of investigation, which should be kept in small bottles with glass stoppers, and the more common of which are named under the head of "Chemical Tests" in the Glossary, which see. A drop of any of these may be conveyed from the bottle to the slide, by means of a very small pipette, or by a glass rod a few inches in length, having one end drawn out to nearly a point; and the pipette or rod should not be used again even for the same reagent, without being first well washed with clean water—"for if this be not scrupulously attended to, there is great danger of conveying some of the substances intended for examination into the test bottle, in which case the whole contents are spoiled. Without the greatest attention to cleanliness, the microscopical observer will be constantly led into error, and thereby bring discredit upon himself and the science." *Beale.*

Test bottles are now manufactured for the purpose of micro-chemical examinations. A cylinder of glass or thin glass tube, is made into a vial, having its bottom flat, and its upper end drawn out to a moderately fine capillary point, which may be stuck into a small piece of cork, or be covered with a small cap of glass or gutta percha. These test bottles are each filled with the test-fluids, to about two thirds of their capacity, by mo

heating each over a spirit lamp, which causes the air within it to expand, then by inverting it and placing the capillary orifice immediately in the test liquid, as the bottle cools, the liquid will rush into it to supply the place of the previously expanded air. Sometimes one operation fills the vial sufficiently, at others it will have to be repeated several times in succession before the requisite amount of fluid will pass into the bottle. When it is required to expel a drop of the contained fluid, the test bottle is held inverted in the hand, the warmth of which expands the air within, and a drop is thereby forced out, without any danger of the preparation under examination being introduced into the test solution.

Mr. Highley has improved upon these test bottles, so that the objection is overcome "that some reagents are decomposed when they enter the heated bottle." He makes a bottle of strong glass, and instead of drawing out its neck to a capillary tube, he has it of sufficient size to pour any fluid through it into the body of the bottle. Then into the neck, a piece of thermometer tube of not too fine an orifice, having one end drawn out to a fine point, is ground, fitting it like a ground glass stopper; over this a cap or cork may be fitted as in the preceding bottles. No heat is required with this, but merely a removal of the thermometer tube stopper, in order to pour in any fluid. And it is then to be closed firmly with the stopper, and used in the same manner as the preceding. These bottles can be obtained of Messrs. Murray and Heath, opticians, No. 43 Picadilly, London, through the house of H. Bailliere, No. 290 Broadway, New York City, or through Robt. Clarke & Co., of Cincinnati, O.; their price is about $5 per dozen.

As beginners, however, most usually have only an ordinary or student's microscope, it may be proper to explain the manner in which they may carry on some micro-chemical experiments, and thereby accustom themselves to such manipulations. First, adapt the focus of the microscope to the surface of the glass plate or slide; then, upon this, spread thinly any non-corrosive precipitate or other chemical agent, which it is desired to test. Lie this slide upon the stage of the microscope, and examine leisurely the character and form of the object. Then, upon one surface of the thin glass cover, spread a drop of acid or other test fluid, and carefully place this surface upon the preparation under examination, and immediately observe the action which ensues, under the

microscope. If it be desired to observe the action of any other reagent upon the resulting combination, there will be no necessity for disturbing the thin cover, but apply the test solution to the edge of the cover as has been previously explained. An entire new manipulation will require an other slide and cover, both of which must be well cleansed.

1. Place a minute portion of carbonate of copper upon the slide, and a drop of nitric acid upon the cover; on contact of these, the carbonic acid of the carbonate will be seen to pass off in globules, while the carbonate of copper gradually breaks down and disappears. In a short time, the field becomes gradually occupied with minute rhombic crystals of nitrate of copper.

2. Remove the cover, in the preceding experiment, place a small drop of aqua ammonia upon it, and return it upon the nitrate of copper on the slide. The crystals of this copper salt will disappear, and gradually, beautiful foliations of the nitrate of ammonia will be observed, interspersed with groups of the still more beautiful prisms of the deep blue ammoniuret of copper.

3. If, instead of ammonia as in the preceding experiment, muriatic acid be placed upon the thin cover, and then returned upon the slide, the nitrate of copper will be changed into a grass-green solution of the muriate, and bundles of spear-like crystals will be seen shooting in all directions across the field of view.

4. Place a drop of solution of iodide of potassium on the slide, cover it, and observe the manner of crystallization.

5. Place a drop of solution of iodide of potassium on the slide, and a drop of sulphuric acid on the cover; on bringing these in contact, the iodine is evolved, and crystals of the sulphate of potash are formed.

6. Place tincture of iodine on the slide, and solution of sulphate of soda on the cover; on contact of these, the alcohol of the tincture takes part of the water from the soda, and the rest of the sulphate of soda immediately crystallizes in prisms. The iodine deprived of the alcohol, is developed in cherry-red drops of liquid, and in dark rhombic crystals. Iodine presents an endless variety of aspects in combination with different agents.

7. Add sulphuric acid to common salt; or to carbonate of ammonia.

8. Add sulphuric acid to bi-chromate of potash and muriate of

soda. The result is crystals of sulphate of soda and potash, with chloro-chromic acid.

9. Add acetic acid to bi-chromate of potash. The crystallization takes place in beautiful forms.

10. Add sulphate of alumina and potash to muriate of cobalt. The crystals of the alum form in great perfection.

11. Add acetic acid to nitrate of copper. The resulting acetate of copper slowly crystallizes in great beauty.

12. Add ferrocyanuret of potash to sulphate of iron.

13. Add nitrate of potash, or solution of potash to sulphuric acid. The sulphate of potash forms in solution. Raise the thin cover with a knife in the smallest degree, and let it fall again; the crystallization occurs instantaneously.

14. The bin-iodide of mercury is a beautiful crystal, and open to a variety of experiments.

15. The smallest drop of any liquid containing lead, may be examined by the usual tests for lead; and wine may, in the same way, be tested in a drop not bigger than a pin's point.

16. Investigate the comparative purity of successive crystallizations of nitrate of potash.

17. Observe the effect of chemical agents on the juices of plants.

18. Observe the effect of a solution of iodine upon starch; and also the effect of a subsequent addition of sulphuric acid upon the same.

19. Place a drop of lime water upon the glass slide, connect it with a few drops of a solution of oxalate of ammonia upon another portion of the slide, by means of a filament of cotton, and observe the crystals of oxalate of lime which, after a time, form at that end of the cotton in the drop of lime water.

"Almost every combination or decomposition known in chemistry can be easily carried on under the microscope, and the action be more accurately observed than in any other way. A little of the manual facility and ocular keenness, which are acquired by practice, being all that is needful; and this is speedily attained.

"But the examination of chemical action may be carried still further by the application of the galvanic battery under the microscope. A small battery of thirty plates, two inches square, is sufficient for the purpose. Place any chemical agent, as liquor potassa, on one glass slide; use a low power to prevent vapor gathering on the external lens of the objective; and then guide

the two wires of the battery near to each other in the drop of liquid. The oxygen will go to one pole, and the potassium to the other. The dendritic foliations that form at one pole and grow out toward the other, in ammonia and nitrate of silver, (and other agents) are very beautiful. The effect visible in albumen, the white of egg, is very interesting. It has long been observed that albumen coagulated on the application of galvanism; the microscope shows quite distinctly what this coagulation is. Albumen is a vesicular structure. The action of galvanism is to burst these vesicles, and draw out the liquid contained in them to one pole, while the vesicles all shrink up toward the other; and their approximation gives the character of whiteness and solidity that appears. The arrangement of these vesicles, and the nerves or bands along which the cellules are arranged, are easily distinguished beyond the possibility of mistake.

"Simple as are these means of observation, thus presented to our notice, they will serve to widely extend our range of philosophical inquiry. The microscope becomes a very effective chemical laboratory, where phenomena connected with chemical action may be examined with an accuracy quite impracticable in larger masses; and for the purpose of analyzing unknown substances, innumerable experiments may be carried on in a short time where the quantities are comparatively insignificant. A door is thus opened into the arcana of nature which the man of truly scientific mind has only to enter, and he will be gratified by an intimate observation of phenomena, connected even with results which are, on the great scale, quite familiar to him, that he will view with unfeigned surprise. A microscopic acquaintance with the minute aspect of chemical changes will bring him into nearer intimacy with substances that he has long known, and guide him to conclusions which have hitherto only worn the dark character of conjecture."—*H. Gould.*

CHAPTER IX.

MICRO-CHEMICAL REACTIONS—SOLUBILITY AND INSOLUBILITY—REACTIONS —EFFERVESCENCE —COLORATION —HEAT —PRECIPITATON — CRYSTALLIZATION—CARBONIZATION AND INCINERATION—DISTILLATION.

MICRO-CHEMISTRY is not only an economic art, but it is a methodic one, by which observations may be multiplied by abridging their duration. In its prosecution we abandon the large and numerous apparatus used on the large scale, for the cell, glass slide, pipette, test-bottles, etc., and act on a field scarcely one three hundredth of an inch in extent. In all micro-chemical processes the first and important condition is to keep the slides, covers, pipettes, etc., in a state of microscopic cleanliness, and to employ only those reagents which are pure, or whose impurities, when these are present, have been determined by the microscope. Without this precaution we may take particles of dust, the debris of clothing, and of the paper-filter, filaments of cotton, etc., for new organs, or even for the result of the reaction. Hence, it is better to place a drop of the reagent on the glass slide, cover it with thin glass, and observe its peculiar color, the number of its impurities, etc., by which means we may more correctly distinguish all the phenomena produced by the reagent upon the material under investigation.

Solubility and *insolubility* are important characters in organic chemistry; and as the suspension of the particles of a body may resemble a true solution, the microscope will enable us to detect the difference by revealing the smallest atoms of the mechanically divided material in a suspension, which are absent in a solution. To determine the solubility of a substance, the smallest portion of it should be placed in a small test tube along with the water, or other menstruum used, and agitated thoroughly; allow it to rest for a short time to observe if any precipitate will ensue. Then, by means of a pipette, place a drop of the liquid on a glass slide, with or without a shallow cavity in the central part of its surface;

cover this with thin glass, and examine it under the microscope by the necessary magnifying power. We may not only, in this manner, distinguish a simple suspension from an apparent solution, but, if required, observe the effects of heat followed by cooling. As air bubbles are an obstacle to vision, and may be mistaken for organic tissues, etc., some care will be required, in properly placing the thin cover on the fluid in order to prevent the formation of these bubbles as much as possible, as well as in the actual examination of the fluid. Should any corrosive fluids be employed in the investigation, they should not be permitted to come in contact with the object-glasses, lest these become ruined thereby.

Where it is desired to study the influence of heat upon any given substance, or to watch the phenomena produced by ebullition, the following course may be adopted;—Procure a plate of brass about one eighth of an inch in thickness, which, when laid upon the stage of the microscope, will extend some two or three inches beyond, and having an orifice in it at that part lying immediately over the orifice in the center of the stage. Over the orifice of this plate the glass-slide, cell, or watch-glass containing the substance may be placed, while a small spirit-lamp applied under the protruding portion of the plate will gradually heat it and the substances resting on it to the required temperature. In some cases, the solar rays may be concentrated upon the liquid, or the substance, by means of a double convex lens, but as this is apt to interfere with vision, it cannot always be satisfactorily employed.

If ebullition be required, a minute quantity of raw cotton (or asbestos), according to the menstruum employed, should be placed in the cavity or cell containing the fluid, so that, when boiling commences, some one or more of the microscopic bodies will become entangled between the felt of two or three fibres of the cotton, and being held therein firmly, resisting all the motion caused by the boiling, the action of the increased temperature upon it, or them, may be more satisfactorily observed. The amount of substance employed should be proportioned to the small quantity of the [illegible] in which its solubility is to be tested. If the fi[illegible] it will appear to be insoluble, even when t[illegible] turated with it.

When organi[illegible] eir solubility or insol-

ubility cannot always be determined by the change in their volume, because the walls or frame-work of these tissues being insoluble in most menstrua, will not appear to have lost their forms or dimensions, although the menstruum has dissolved all the material contained in their interspaces. Indeed, the menstruum may substitute itself for these materials, or may penetrate with them into all the cavities, so that the minute cells will appear to be as well filled and distended at the close of the operation, as they were at its commencement. In such cases we can only determine the loss sustained by the tissue, after having removed it from the fluid and thoroughly dried it on a glass slide.

Some bodies are very soluble, which solubility may be at once recognized by placing a small portion in a drop of water, and then submitting it to microscopical observation. While others require considerable time before yielding to the action of a solvent; hence, the insolubility of a body in a menstruum should not be pronounced too hastily.

We may know when solution is going on, when striæ are observed escaping from the margins of the substance in the menstruum, having the color of the substance, or perhaps a refracting property different from that of the menstruum. This phenomenon frequently produces an apparent effect upon the fluid, similar to that caused by the movements of the cilia of animalcules. This appearance is instantly presented when oil is added to sulphuric acid, or camphor is placed in alcohol; the drop of oil, or the fragment of camphor, display ciliary motions on their borders, which come and go, and impress upon the liquid gyratory movements, which are terminated by removing drops or atoms of the substance and drawing them within their vortex. This phenomenon is a simple hydraulic effect, and is to be explained in the same manner on this minute scale, as for eddies on a larger one.

This is a much more interesting sight, when effervescence accompanies the solution, as when, for instance, small fragments of chalk are dissolved in a dilute acid. The carbonic acid of the chalk, driven out by the fixed acid, escapes in gaseous bubbles, which succeed each other and disappear with the rapidity of lightning, causing the fragments to pirouette excessively. In escaping, these bubbles repel the fluid as much as the piece of carbonate.

By submitting the same substance to the action of various menstrua, we find that many microscopic bodies which have been mistaken for tissues or organs, are only grains or globules insoluble in water, but soluble in other fluids; and that many substances looked upon as soluble in all proportions in a liquid, are only held in suspension. We should not conclude that a body which floats upon water even after alcohol has been added to it, is insoluble in alcohol,—for a substance soluble in alcohol, may not be so in alcohol diluted with water. By waiting until the fluid has evaporated, and the body is dry, we may then add absolute or rectified alcohol, and ascertain whether these bodies are insoluble organs, or resinous or oleaginous matters, by their solubility or insolubility.

Globular insoluble organs, and insoluble globules may be distinguished from each other by the following rules: All fluid substances which are insoluble in another fluid, but are of a less density, arrange themselves in this fluid in lenses or globules when separated by agitation; upon resting, these small globules will be observed to approach each other, unite, form larger ones, and finally float upon the heavier fluid in a layer of more or less thickness and extent, especially when the substance is of homogeneous density throughout in its composition—as in the case with oil and water.

But instances frequently occur in the study of organic bodies, where these insoluble particles possess different densities, so that some will remain longer than the others at different depths. In such case, the particles are arranged in perfectly spherical globules which refract the rays of light in such a manner, that they appear black with a small luminous point in the center, and when very small, may be taken for so many parts which have separated from the tissue while tearing it apart. The different degrees of density indicated by the depths at which these atoms or globules are held in suspension by the fluid, are owing to the character of the liquid and the different quantities they contain of foreign substances.

To ascertain whether globules observed under the microscope are organs, or oil-globules, resinous drops, albumen, etc., they should be tested by analysis. Thus, a solution of some essential oil in alcohol, when added to water will present a milky appearance to the eye; but, when viewed under the microscope
of globules having the same diameter and the sa

power will be seen moving with tempestuous rapidity, and resembling monads in motion. As soon as the fluid has evaporated, these globules rest motionless on the surface of the slide, and we may now satisfy ourselves of their nature by a drop of alcohol or ether, which causes them to instantly disappear. All substances precipitated in liquid form from a menstruum previously holding them in solution, take the globular form; and the more regular the precipitation, the more the globules resemble each other in form and diameter.

If the white or albumen of egg be placed in a ground stoppered flask and dissolved in concentrated hydrochloric acid, after some hours the liquid will assume a purple and then a violet tint. Then, if the fluid part of the solution be allowed to evaporate spontaneously in a glass dish, a white powdery layer will be formed, which, under the microscope, will be seen to consist of handsome white spherical globules of equal diameters. These are globules of albumen, which may be again dissolved in concentrated hydrochloric acid. All other volatile menstrua in which albumen is soluble, leaves it under the same form, if evaporated with the same degree of regularity.

Gluten or vegetable albumen presents the same phenomena, when the ammonia, or volatile acid holding it in solution is allowed to evaporate.

When a solution is composed of two or three different substances, the form and dimensions of these globules will vary. Thus, if sugar and oil be dissolved in boiling absolute alcohol, a syrupy precipitate will be produced on cooling, which, under the microscope, will be seen to consist of fine, limpid, isolated globes yet in contact with each other, and differing in size, some being as much as twenty times larger than the others; they will somewhat resemble cellular tissue having distinct, clear, and almost disaggregated cellules. Sometimes the larger globes will be aggregated with one or more of the smaller ones, appearing like large cellules with smaller ones, and resembling those green cellules which are disaggregated in water by tearing the tissue of thick fleshy leaves.

In the micro-chemical examination of a body, after having carefully placed it on a glass slide, we must thoroughly examine it under the microscope, to ascertain not only its general appearance but also that of those substances which surround it, so that we

may not mistake them for results, when they become displaced by the motion of the reaction. On a thin glass cover, the reagent should be submitted to the same inspection, (unless it be very volatile); then place the cover upon the substance, and, under the microscope, closely watch the reaction from its commencement to the end. If a clear idea be not attained, repeat the operation, and then pass on to other reactions following the same course.

In other instances, the substance on the slide may be covered with the thin glass, near which a drop of the reagent is placed, and which may be conveyed to the edge of the thin cover, by means of a steel, platinum, or glass point, according to the nature of the reagent; this is placed within the drop of the reagent, and moved along on the surface of the slide toward the cover, in such a manner, as to carry some of the fluid along, and which enters between the slide and cover by capillary attraction. If one drop be not enough to effect the reaction, more may be used. Instead of a needle point, some of the reagent may be conducted to the margin of the thin glass cover by means of a pipette; but Highley's test bottles will be found a superior article for this purpose, as each bottle contains its own fluid, pure, and not liable to contamination or dust, and from which a small drop may always be obtained, when the bottle is inverted, by the mere heat of the hand.

The reaction termed *effervescence*, is produced by the rapid escape of gas, and may always be observed under the microscope, as gases develop themselves in fluid under recognizable volumes whatever may be the quantity of the substance operated upon. If, in a liquid under observation, a rhomboedre or an opaque block of the minutest size is seen, which remains insoluble until diluted nitric, hydrochloric, or acetic acids are brought into contact with it, and then evolves black bubbles which disappear and escape from the liquid nearly as fast as they are set free,—the crystal or block disappearing at the close of the effervescence,—we will know that the crystal or amorphous fragment was a carbonate, which in organic tissues and fluids is almost invariably of a calcareous nature, as we may verify by other reactions. If, however, the crystal is soluble in the liquid, requiring no acid to render it so, it is a carbonate or bicarbonate of potassa or soda, salts which are more frequently met with in organic chemistry, and the character of which may be determined by other reactions.

Suppose, after a liquid has evaporated, a crystalline deposit is left upon the slide, and we wish to determine whether it is a hydrochlorate; it must first be treated with a dilute acid, which will dissolve it without effervescence, and, on evaporation, will deposit it a second time in a crystalline form. If, on the other hand, the deposit be treated with concentrated sulphuric acid, a brisk effervescence will ensue, bubbles of gas will rapidly escape, and the crystal will appear to sport in the little tempest emanating from its bosom, until it enters into combination with the sulphuric acid.

If a caustic alkali, as for instance, potassa, when added to a liquid or crystal under microscopic observation, causes an evolution of gaseous bubbles, it is an indication of a salt containing a fixed acid with ammonia for its base. And in this way are other substances determined, viz., by the nature of the agents causing effervescence, as well as the products resulting therefrom.

Another valuable reaction under the microscope is that of *coloration*, in which the substances acted upon are colored by the reagents used. The *aqueous solution of iodine* colors the tissues yellow, but should it, instead, produce a more or less deep blue or violet color, it is an indication of the presence of starch. The indication will be less valuable if the blue coloration is produced on the liquid under observation, and not on the tissue—for iodine equally colors blue pollen-grains and resin of guaiac. Alkalinity of the liquid will prevent this reaction of iodine, so that as a general rule, it is better to previously acidulate the fluid; a large quantity of iodine may act without requiring the acidulation, but if the tincture be used for this purpose, it will coagulate some liquids, and thus interfere with vision; the coagulum produced may also envelop any starch globules which may be present, and prevent the iodine from acting upon them.

Ferro-cyanuret of iron acidulated, colors the tissues and ferruginous liquids blue, and this color is as distinct under the microscope as elsewhere, whatever may be the size of the object.

Nitric acid colors albuminous tissues yellow; *hydrochloric acid* colors them at first purplish, and then blue; *concentrated sulphuric acid* coagulates them white at first, then blackens and chars them; it acts in the same manner upon all organic tissues of whatever nature, whenever they are submitted to its prolonged action—it finally resolves them into black globules, and these, into other globules of less size. The same results ultimately

occur when organized tissues are acted upon by concentrated hydrochloric acid or any of the strong mineral acids, except, the nitric, which dissolves and transforms them.

Sulphuric acid colors sugar yellow, and the oils a brick color. If the acid holds albumen or olive oil in solution, it produces a magnificent purple color with all saccharine juices; if it holds sugar in solution, it gives the same color to oils, and animal or vegetable albumen. According to Elsner, cane sugar is colored the same by arsenious acid.

Alkaline liquids, (and under the microscope we should always prefer ammonia diluted with water) impart a blue color to the cellules of certain tissues naturally colored purple. The weakest mineral or vegetable acid, colors purple the cellules of certain tissues filled with a substance of a blue color. For the same reason, an acid will redden an infusion of litmus,—and an alkaline solution will restore the reddened infusion to its original blue.

Solutions of Copper color those tissues blue which contain ammonia either free or in excess.

Chloride of Platinum has a pale yellow color under the microscope, and it requires some experience to distinguish it from the yellow color it imparts to ammonia and potassa. In crystallizing by evaporation, this reagent becomes colored almost the same as if it were combined with potassa, and its crystals assume nearly the same form as when this base is present; these are hexagonal plates separated from each other. Now, as under the microscope, the yellow color is that which admits of being less distinguished than others by its shades, as a general rule, the platinum reagent will give but very faint indications, except in some instances, when we proceed in a comparative manner.

Nitrate of Silver denotes the presence of hydrochlorates in the microscopic drop, by first disturbing the transparency of the liquid, and then, by a prolonged exposure to the air, coloring it somewhat violet.

If an organic substance contain free sulphur, add potassa or soda to form a sulphuret, and then add *nitro-prusside of sodium*, heat, and a beautiful purple color will be the result, (*See Chemical Tests for Urine*, §10.) If the sulphur exist in the form of a sulphate, fuse it with carbon so as to form a soluble sulphuret, and then add the nitro-prusside as above.

When peroxide of iron is present in the tissues, *sulphocyanide of potassium* will produe a blood-red color; *ferrocyanide of potassium* blue; and *salycylic acid* a purple.

If the protoxide of iron be present, the *ferridoyanide of potassium* (or red prussiate of potash) will produce a blue color; solution of *tannic acid* or *tincture of galls*, a black.

Hydrosulphuret of ammonia will cause a black color with either of the above oxides of iron.

Molybdic acid separates phosphoric acid from iron of a yellowish color; tin will do the same forming a phosphate of tin. *Molybdate of ammonia* detects phosphoric acid in protoxide of iron.

Cells filled with wax lose their opacity, and are colored a very pale-yellow by *ammonia*, and, on evaporation, the wax is left in plates clear as water.

Cells rendered opaque by the presence of a solid resin, or which strongly refract the light, through the essential or fixed oil contained in them, of a blue color, become discolored, acquire a constantly increasing limpidity, and terminate by suddenly flattening, when kept for a longer or shorter time in *alcohol*, *ether*, a *weak acid*, and even in *olive* or other *oil*.

Tissues rendered opaque under the microscope by the presence of various crystals, resume their natural transparency in a *weak* or *strong acid*, if the crystals are salts, or, in *liquor potassa* if they are siliceous. Tissues whose opacity is due to the presence of mucilage, gum, liquid albumen, or a salt in solution, are rendered transparent after a longer or shorter sojourn in *distilled water*.

On the contrary, *alcohol* or *ether* give opacity to cells containing gum or liquid albumen; these reagents also granulate and corrugate glutinous and fibrinous membranes. All cells filled with air or gas are black, when observed in a layer of fluid.

The various organic substances are lodged in microscopic cells which are often separated by the minutest intervals, as by the simple thickness of the two membranes enveloping their respective walls; and by these microscopic reactions we may readily ascertain their presence or absence, measure the exact space which each one occupies, and even draw the most complicated tissues in as many various colors as an ordinary map. If by the preceding micro-chemical reactions negative or equivocal results are obtained, we may then have recourse to heat.

Almost all the reactions by *heat* are obtained by fusion,—the reagents are termed "fluxes,"—and the result is a very minute vitrification. The fluxes more frequently employed are, *carbonate of soda*, *borax*, *nitre*, *vitrified boracic acid*, and *double phosphate of soda and ammonia*, all of which should be purified by crystallization and then reduced to fine powder,—also, an *aqueous solution of nitrate of cobalt; tin*, *iron* and *lead* in the metallic state; *oxide of copper*, and *powdered rock-crystal.*

When it is desired to ascertain the nature of a substance by the action of fluxes we place a minute portion of it in a small cupel or platinum cup, and then cover it with the powder of one of the above fluxes, or, we may place it in contact with one of the three metals. By means of a blowpipe the heat is gradually raised,—the flux boils, concentrates, dissolves the substance, or promotes its fusion, reddens, and, if allowed to cool spontaneously, the solution forms an enamel, the color of which is an affirmative or negative indication, and of which we take note. This cupel is set aside, and in a new cupel another reaction is tried upon some of the same substance by means of a new flux, taking care to observe all the indications by a lens, or, in many cases, by the microscope. The inorganic substances which are more frequently met with in the organic kingdom, and which may be recognized by the fluxes even in the minutest quantity, are as follows:

Carbonate of lime, under the blowpipe, gives a dazzling, white light. *Calcareous* salts with organic acids, give a similar light under the blowpipe. Chalk may be recognized in a simple fiber of cotton, by holding it in the white light of the flame of a lamp or candle,—the fiber shrivels or curls up, blackens, and incinerates, without hardly changing its form; and, under the blowpipe, the cinder sheds the dazzling light characteristic of the presence of lime. And so with many other tissues.

Magnesia, free or combined, on cooling assumes a more or less intense flesh color with the solution of nitrate of cobalt.

Alum, free or combined, assumes a fine blue color with the same fluxes which can be only well distinguished by day-light.

Baryta, with the same flux, becomes red-brown, brick-red or rusty-yellow, while being heated, but loses all color on cooling.

Strontian, with the same reagent, becomes black and does not fuse.

Silica, assumes a bluish tint, which becomes black when more cobalt is added.

Manganese fuses with borax, and assumes the color of amethyst which is lost on cooling; but if a little nitre be added, this color remains. By this process we may verify the presence of manganese in the paring of an apple.

Iron is revealed by borax. At the oxidating heat, iron assumes a sombre red color which ends in a yellowish tint; at the reduction heat, and, in all cases when a little tin is added to the mixture, a green bubble will be obtained, sometimes quite dark.

Lead only oxidizes yellow; with soda the oxide becomes yellowish, and opaque on cooling. By fusion, the oxide assumes a fine orange-green color, which is finally reduced, with effervescence, to a globule of metallic lead. With borax, and in adding a small grain of tin, the oxides of lead become more or less intensely black.

Zinc fuses and sublimes, or, oxidizes in white flowers. The salts of zinc assume a green color with the cobalt solution.

Arsenic and *Arseniates* evolve a garlicky odor, and disappear wholly or in part, by oxidation and vaporization.

Antimony evaporates in white smoke, evolving a pungent odor.

Copper, its salts and its alloys, assume a fine red color with borax, to which pure tin is added during the fusion.

The oxides and salts of *mercury* deposit a globule of metallic quicksilver with soda. Cinnabar alone volatilizes without residue, evolving at the same time an odor of sulphurous acid; it is the same with the bi-chloride of mercury.

Micro-chemical reactions furnish indications of a phosphate, when *phosphate of lime* is in the tissues in a crystalline state. This will be again referred to under crystallization.

These are nearly all of the most valuable reactions which require the use of the blowpipe in the investigation of organic substances; they are principally confined to the verification of the presence of metals which naturally exist in the ashes of the substances, or which have been accidentally introduced into the tissues. When it is desired merely to ascertain whether the substance under examination belongs to the organic or inorganic kingdom, there is no necessity for the blowpipe in the first instance; it will be sufficient to hold the substance in contact with the white zone of the flame; because heat developed by combustion rises

to a much greater temperature than is required for the decomposition of organic substances. The characters presented by organic matters decomposed by heat, are curling or shrivelling up, twisting in various ways, swelling up, boiling, blackening with evolution of more or less fuliginous and ammoniacal smoke, and finally, incineration.

Precipitation in micro-chemistry is carried on in glass cells, or, when we can, on a glass slide with a plane surface. The cell or cavity made in a slide, in the segment of a sphere, acts somewhat as a lens, and refracts the rays, instead of transmitting them to the microscopic object in the same manner as they are reflected by the mirror, and hence should not be used. When a substance is precipitated by a reagent it produces in the fluid, plates or layers, more or less colored, corrugated, or embossed, resembling clots of albuminous tissues; regular crystallizations; large clear globes or globules of similar appearance and diameter; or, minute opaque points or granules scarcely measurable, which interfere with the transparency of the fluid, and remain more or less distant from each other.

But this kind of reaction exacts much care and address on the part of the observer, and more especially so, when the substance examined is very small in quantity, and the mixture is very complicated. An opinion should not be formed as to the phenomena produced and their indications, after only one trial.

Crystallization is one of the phenomena of precipitation, which, in micro-chemical analysis, furnishes the readiest and most happy results; for it presents the substance under a definite form and position, which allows us, after having measured its angles and outlines, to treat it with any of the reagents above named, without fearing the disturbances caused thereby in the mixture; so that with a crystal the two thousandth of an inch in diameter, we may arrive at as certain results, as if we had operated upon several pounds of the same material on the large scale. As the reactions have already been named, it will be necessary here to refer to the goniometrical processes by which the angles of crystals are measured under the microscope. This is accomplished by an instrument attached to the eye-piece of the micrometer, termed a *goniometer*, *see* Glossary.

It should always be borne in mind that under the compound microscope, measurements are effected by the aid of transmitted

light; that, consequently, every surface of the crystal which is not parallel to the plane surfaces of the glass, will appear black. With magnified crystals, all the parts which appear black or dark, indicate that the surfaces are inclined upon the plane. On the contrary, those surfaces which appear clear, are parallel to the plane. And we may see, in turn, those which are wholly or in part black, as the movements in the fluid causes them to incline at different angles with the plane surface of the slide.

But, when the inclination is not very great, we observe the lateral surfaces drawn, so to speak, upon the clear surfaces, and apparently diminishing their extent. To obtain a correct idea of the general structure of a crystal, that is to say, the number of its surfaces, the simplest method is to gently move it in the liquid, without carrying it out of the field of view, making it roll and turn upon itself. This may be accomplished by means of a drop of alcohol placed in the liquid containing the crystal; during its evaporation, the alcohol, if in small quantity in the liquid, impresses upon the crystal a motion favorable to this kind of observation. If the crystal is soluble in the liquid, we should saturate this with the fluid in which the crystallization had been observed, (the mother-liquor) and then the crystal will be insoluble in it.

The following example will illustrate the indications which we may derive from the movements of a crystal, as to its general form. Place a crystal of oxalate of lime in a fluid, and impart motion to it, as above described; in rolling under the inspection of the observer it will present in succession, an entire clear longitudinal face; then two parallel longitudinal faces, the one clear, and the other dark; then three faces equally longitudinal and parallel, the two extremes dark, and the median much narrower and clear; and then it will return to its first aspect, presenting a simple and unique clear face, hardly bordered with two dark lines or traces. Now, if the laws of refraction are called to mind, it will be evident that like images, under the microscope, can emanate only from a prism of four faces and a rectangular base; because a prism of this kind ought to appear with a single clear face, when two of its faces are parallel to the glass slide; and, when inclined obliquely on the plane surface of the slide so that the rays of light fall obliquely on its inferior faces, it will present two dark lines and a clear one.

Now, if on the other hand, we are observing a prism with six

[illegible] which is turning on its axis by the effect of the evaporation of the fluid in which it is deposited, it is evident, that in whatever position it may be placed when at rest, it will always present under the microscope, by refraction, three longitudinal and parallel lines, the two extremes being dark, and the median clear. In fact, every time the crystal is at rest, it will lie with one of its faces upon the slide.

In the examination of crystals we must be careful not to be deceived by illusory appearances which give to quadrilateral or square crystals, a fusiform appearance, but which is not common with good microscopes, neither should we confound depressions with elevations, and vice versa. Organic tissues should not be mistaken for crystals, because, compression of cells or organs, will frequently impress facets upon them, causing them to resemble crystals; and we may determine this point by testing with reagents, as, dry heat, boiling in water or alcohol. If they be tissues, the boiling in water will cause them to assume the form of globules; and in alcohol, they will empty themselves, and present only a little sac or vesicle more or less torn. All substances presenting the appearance of crystals should be examined when dry, in fluid, and under the influence of reagents, so that no error may be committed in deciding upon their nature.

Carbonization and *Incineration* do not require large apparatus when it is desired to observe their effects under the microscope. Place the tissue under examination between two thin plates of glass, hold this apparatus with the plane surfaces exposed to the white part of the flame of a lamp or candle; the tissue being protected from atmospheric action by the glasses [illegible] not incinerate; but being deprived of the [illegible] tion, it will not hold any of the [illegible] formation or frame-work except [illegible]

To incinerate a body, it must [illegible] gradually exposed to the flame of [illegible] red hot charcoal. In [illegible] allow any of the [illegible]

Before carbonizing or incinerating [illegible] only study its external [illegible] its constituents [illegible] rectly [illegible]

as well as to prevent us from committing any mistake in the reactions to which we may submit the disorganized substance.

The glass slide holding the substance to be acted on by heat, should be gradually exposed to the flame, and likewise withdrawn in the same manner; and it must not be placed upon the stage of the microscope until it has become cool.

Burning or incineration requires no other apparatus, and frequent recourse will be made to it in micro-chemical analysis for the determination of the nature of crystals. A crystal, whose forms and principal reactions have been observed on the glass slide which serves as a crucible, is exposed to the action of heat; if, after the burning, it is found to effervesce with acids, this will be a proof that its acid was vegetable, and that heat has converted it into a carbonate. Sulphate of lime, obtained by precipitating lime water with sulphuric acid, crystallizes rapidly in needles, which more nearly resemble the crystals of phosphate of lime, both in size and structure, than any other crystals which have been observed in the tissues of plants; and it will be somewhat difficult to distinguish them by analysis, as they both offer the same conditions of solubility and insolubility in water and acids, and combined sulphuric acid presents no special reaction which is not proper to phosphoric acid. But these two products may be distinguished from each other, by burning them,—the small crystals of sulphate of lime will lose their water of crystallization, contract, and fall into small pieces, like a bead of grains rendered opaque and dark by refraction; while, the needles of the phosphate of lime, at the same temperature, will preserve their form, their crystalline appearance, and their original transparency.

In stating that the crystals of salts with vegetable acids carbonize by heat, moderate heat only is intended; because, if the glass slide which serves as the crucible for the crystal, is held for some time in the white heat, the crystal, after cooling, will dissolve in acids without effervescence, in consequence of the carbonate having been reduced to an alkali. A white heat expels the carbonic acid from the crystal, the same as the gaseous elements which were associated with it, constituting a peculiar acid, had been expelled by the moderate heat. If the alkali produced by the white heat be exposed to the air for some time, it will absorb carbonic acid, and will then effervesce with an acid.

By means of a powerful refractive lens, concentrating the solar

rays on the substance, we may easily carbonize crystals with vegetable acids, and reduce the carbonates thus formed to alkalies, under the very eyes of the observer. The alkalization of calcareous crystals is manifested by a dazzling incandescence.

The progressive effects of the artificial disaggregation of tissues, may be studied by the action of acids or alkalies, hermetically enclosing the reagent and the tissue in the cavity of a glass slide, or cell. On the other hand, the effects of spontaneous disaggregation of tissues in water and under the action of the atmosphere, may be observed in glass cells, covered with thin glass, in order to prevent the too rapid evaporation of the fluid. These little cells may be of various sizes suited to the investigation, and will be found very convenient for a crowd of observations, among others that of the cellular circulation of the *chara vulgaris*, as well as the circulation in tadpoles and other transparent animals.

For *distillation* in micro-chemical analysis, a small retort, an adapter, and a flask with two tubulures are the only apparatus required, and with these we can obtain the desired results with but little loss of time and at a small expense. Indeed, when it is not desired to collect the volatile or distilled material, a glass tube closed at one end, and bent upon itself, will be sufficient, or, a tube also closed at one end, but bent into two or more folds or branches, and which may be permanently held in a convenient position by means of a supporting bar. In some instances, a glass cell will answer. Now, if the substance under investigation be placed in the cul-de-sac or closed end of the tube, and this be submitted to the heat of a wax candle, spirit lamp, or hot-water bath, evaporation will ensue, and the vapors set free will condense in the first branch, or in the succeeding branches, if there be more than two. By means of this little apparatus the products of the distillation may be reduced, by such degrees of temperature as will be required to condense each of them; and if the experiment require it, the condensed liquids in each of the branches of the tube may be successively submitted to the lamp, without in the least disturbing the apparatus. Each product may be separately investigated under the microscope, as well as by means of reagents, by cutting each branch containing them, at its bent extremities, and, if necessary, removing the product upon a slide.

There is not much difficulty in driving out the products unmixed;

but the greatest difficulty will be to convey the substance under examination to the bottom of the cul-de-sac, without any of it becoming attached to the walls of the tube against which it glides, and which will disfigure each product, or cause it to be misrepresented. This inconvenience may be avoided, if the substance is consistent enough, by forming it into small balls, kneading it with grains of sand, or powdered glass; thus mixed, each little ball will roll down to the bottom of the tube without leaving any of its substance on the walls of the tube,—and the sand, instead of interfering with the distillation, will cause it to proceed more rapidly, by dividing the substance acted upon.

If this substance be a fluid, and is decomposable by heat, we may remove all that portion of it which is attached to the walls of the tube, by carrying the flame along it, and at a proper distance from the closed extremity which serves as a cucurbit, heating it even to redness, if necessary. If it is only partially decomposable, the walls of the tube may be washed with some volatile menstruum which will dissolve it, and which may be conveyed down to the cul-de-sac, by properly inclining the tube; and to remove all traces of the volatile menstruum, after having washed the tube-walls, a proper degree of heat may be applied to all parts of the tube, commencing close by the side of the cul-de-sac, and carrying the flame along the branches and curved parts toward the open extremity. Each branch of this apparatus may be thus used as a receiver, and may be submitted to microscopic observation, so that each product can be investigated after its condensation. If the walls of the tube are of clear glass and flattened so as to extend its cavity between two horizontal walls not too far apart from each other, the observation will be rendered more distinct.

In some instances, the substance may be placed in the cavity of a glass slide, which is then covered with a glass or copper cell, having a piece of thin glass to form its upper surface. If the cell be made air tight upon the slide by proper luting, and cold water be kept upon the thin glass, by means of a wet rag or otherwise, when the proper degree of heat is applied to the slide, the distilled product will condense upon the thin glass, and may be subsequently inspected under the microscope.

Instances may probably occur in which the vein or tube of a plant may, under the microscope, act as an alembic for the sub-

stance which it encloses; being heated and illuminated at the same time. In this manner the fusibility or volatility of the included substance may be observed; fusion manifesting itself by a greater and purer transparency, and volatilization by strongly refracting globules which move themselves to a distance from the focus of heat, toward the most elevated side of the tube in which they form.

Further instructions regarding micro-chemical analysis, will be found in the succeeding chapters on Urinary Deposits and Vesical Calculi, and in the Glossary under Chemical Tests, and Preservative Fluids. The young micro-chemical observer may, however, derive some benefit from the following statements:—

Alcohol coagulates gum, or dextrine; the presence of nitrogenous substances is proved by the action of concentrated sulphuric acid, which produces a rose-red color,—or, by solution of iodine, or of chloride of zinc and iodine, and also by nitric acid, with ammonia subsequently added to it,—in either of these three cases an intense yellow color, almost brown is produced. Starch becomes blue on the addition of iodine; inulin is turned a pale yellow or brown by iodine; green chlorophylle loses its color with alcohol; albumen when mixed in water with sulpho-cyanate of iron produces a blood-red color, which is removed when a few drops of ammonia are added; water added to the blood corpuscles thickens them, and an excess of water causes them to swell out until they rupture; some other agents produce a similar effect, as ether, potassa, alcohol, etc. Acetic acid renders the blood corpuscles clear and transparent, ultimately dissolving them; they may be seen more distinctly after the addition of tincture of iodine, or of a saturated solution of corrosive sublimate. They become yellow with chloroform, which renders their middle portion much more distinct than their margins. The white corpuscles of the blood are rendered more distinct by water; and acetic acid coagulates the contents rendering the nuclei distinct and yellowish, and the margin quite clear. Fibrin coagulates spontaneously, is insoluble in ether, alcohol, or water, and is precipitated from its solutions, when acidulated, by ferrocyanide or ferridcyanide of potassium.

CHAPTER X.

EXAMINATION OF VEGETABLE ORGANS, AS ROOT,—WOOD,—CAMBIUM,—BARK,—RAPHIDES,—ROTATION,—LEAVES,—FLOWERS,—POLLEN,—OVARY,—SEED.— ALGÆ,—FUNGI,—MOSSES,—FERNS,—LICHENS,—LIVERWORTS, ETC.

HAVING now given in as concise a manner as possible the practical points connected with the use of the microscope, a chapter or two will be devoted to examinations of some botanical specimens, as well as of certain parts of the human body, for the benefit of those who may desire to know some of the principal points to be attended to in these departments of microscopy. Much of the matter in these chapters will be selected from Schaht, the Microscopic Dictionary, and Beale on the microscope.

In the vegetable kingdom, the chief points of attraction, are the *stem and root*, the *wood*, the *cambium*, the *bark*, the *leaves*, the *flowers*, the *fruit*, the *pollen*, *spores*, etc.

The *Stem* and *Root*. These should always be examined while in a recent state. Thin sections should be made transversely, obliquely, and longitudinally, for the purpose of studying the arrangement of the cells, etc. They may be prepared in the same manner as directed for the *wood*.

The *Wood*. The woody structures of plants are developed from the cambium, and consist of cells, fibers, pitted and spiral fibrous structures, and secondary deposits. Thin sections should be made transversely and longitudinally in order to illustrate these several structures, as well as to ascertain the character of the medullary rays; by this plan some beautiful and interesting objects may frequently be had.

The peculiar arrangement of the medullary rays, whether long or short, narrow or wide; the presence or absence of annual rings, their limits, and feeble or strong development; pores, large or small; pits present, their size and position; cells, their form, arrangement, contents, etc., are all to be noticed. Turpentine or

resin canals may be ascertained by macerating the object in ether or absolute alcohol, which will dissolve these substances. The sections may be made with a very sharp knife or razor. When the wood is very hard, it should be softened, previous to making thin sections, by allowing it to soak in water for twenty-four or forty-eight hours. If the sections roll up or fold together, they must be placed in a small quantity of water under a simple microscope, and spread out by means of a needle or two; immediately after which, a cover of thick glass should be placed over them to keep them pressed out flat. When it is desired to study the isolated cells, they may be procured by Schultz's method of maceration, as explained in the glossary, under the head of "Chemical Tests," *nitric acid*.

The Cambium, consists of extremely delicate, slender, elongated cells, and which may be observed in sections made near the growing points of stems, as in terminal or axillary buds. The cells consist of delicate cellulose cells enclosing a primordial utricle, nucleus, and abundance of nitrogenous protoplasm, but usually without chlorophyll. As the cambium forms wood on one side and bark on the other, attention must be paid to its connection with these two substances, between which it is usually placed. Cambium never contains starch or other hydrates of carbon; its contents are granular, and should always be first tested with a solution of iodine, and with sugar and sulphuric acid; when fresh, it is rich in nitrogenous substances, having a rose-color imparted to it by the latter chemical agents. If the transverse section be made smooth and thin, the cambium cells, their number, arrangement, contents, etc., may be distinctly seen. The cells may be rendered more transparent by adding a drop or two of a weak alkaline solution to them, which removes the granular contents, and enables the observer to distinguish the part which forms the wood and the vessels from the part which produces the medullary rays.

The Bark. Longitudinal and transverse sections must be made of this substance, which will be found to vary considerably in its character, in different plants; considerable difficulty will be found in obtaining perfect sections. The bark last formed by the cambium is termed the "secondary bark," in which may be found short or long cells called "liber cells;" they may occur either isolated or in bundles, and are ordinarily composed of cellulose,

which gives a blue color by the application of iodine and sulphuric acid, or the iodized solution of chloride of zinc. Corky substance, either externally or internally, may often be observed, and its character should be noted, whether smooth and leathery, or spongy.

The Leaves. Thin transverse and longitudinal sections must be made through the leaf. Transverse or vertical sections of leaves, petals, etc., may be easily made with a sharp razor when they are firm and thick; but when they are delicate, it will be required to split a very soft cork, place the leaf carefully between the pieces and then slice both together, being careful not to make too severe pressure on the leaf or petal; then place the fragments in water and pick out the pieces of the leaf with a needle. Many small simple leaves make good objects by drying, soaking in turpentine, and mounting in balsam; the same may be done with petals, sepals, etc. The epidermis of a leaf should be examined to ascertain whether it is the same on both sides of the leaf, and whether stomata are present or absent; if present, their construction, position, arrangement, and extent, whether the whole surface of the epidermis or only parts of it contain them, and whether they are on a level with the epidermis, raised above it, or depressed below it. If thin transverse sections of the cuticle be treated with the iodized solution of chloride of zinc, or, concentrated sulphuric acid, by boiling with caustic potash, or by maceration according to Schultz's method, it will be found to consist of an external structureless secretion from the epidermal cells, and an internal layer of chemically altered epidermal cells. The character and contents of both the epidermal and parenchymal cells must be noted. In some leaves, crystals will be found; also raphides, which may likewise be met with in any other part of the plant.

Raphides occur singly in the form of octohedra, rectangular and oblique prisms, or, in the form of stellate masses, or, in bundles of sharp-pointed crystals. They vary in size from the $\frac{1}{80}$th to the $\frac{1}{1000}$th of an inch, and are composed of phosphate, oxalate, tartrate, malate, or citrate of lime. They are always situated in cells. They have been produced artificially, as follows: place a piece of rice-paper in lime-water under an air pump, in order to fill the cells with the fluid. Dry the paper, and repeat the process several times until many of the cells are charged with lime

water. Now place pieces of this prepared rice-paper in weak solutions of oxalic and phosphoric acid, and allow them to remain for three or four days, when the raphides will be noticed.

The transparent leaves of some water-plants are very favorable for the observation of the *rotation* or circulation of the cell-protoplasm, as the *Chara vulgaris*, *Vallisneria spiralis*, *Nitella flexilis*, *Nitella hyalina*, *Hydrocharis morsus ranæ* or *Frog-bit*, *Anacharis alsinastrum*, *Hottonia*, *Ceratophyllum*, etc.; it may also be seen in the hairs of *Senecio vulgaris*, etc. To obtain a view of this movement, take a leaf of Chara, and place it on a slide in water, and examine it by a $\frac{1}{4}$ inch objective. Should the leaf be encrusted with carbonate of lime, so as to interfere with obtaining a view of the rotation, the crust must first be removed by a weak dilution of sulphuric acid; the growing points of the leaves will usually be found the most transparent. In Vallisneria the leaves being thick, they should be divided, by means of a sharp knife, into horizontal sections. After separating or dividing a leaf, the motion will at first cease, but will be restored after a time, by means of moderate warmth.

Flowers. The petals afford many interesting objects in the epidermis, glandular and other hairs, the color-cells, and the veins composed of spiral vessels. Entire petals of small size and delicate character form good objects when dried and mounted in Canada balsam. The larger kinds are studied by means of sections, the same as *leaves*. The form of the petals, their color, the fluid contents of the cells, and the nature of the exterior of the petals must be noticed. Delicate vegetable tissues may frequently be formed into sections fitted for examination, by saturating them with a thick solution of gum arabic, drying them slowly in the air, and then dividing them, when this is necessary.

In examining the *Stamens*, attention must be paid to the anthers, making a transverse section through an anther, while in the bud. The cellular structure of the walls of the anther must be observed; whether its epidermis is provided with stomata or not; whether its fibrous cells are spiral, annular, reticulated, arched, etc.; the position of these cells, whether they form the outer or inner layer, etc. The contents of the anthers, the *ripe pollen*, must also be carefully considered. Each pollen mass must first be examined separately, and afterward the individual grains of pollen. Fresh pollen should always be had, in order to examine the structure of its

coatings, the places for the egress of the pollen tubes, their number and disposition, and whether they are provided with opercula; the color of the cuticle when acted upon by sulphuric acid, should be noted. The *pollen-grains* should also be examined as to their form and structure, contents, and development. Ripe pollen and pollen grains should be examined dry, as opaque and as transparent objects; in water, in oil of lemons, and in concentrated sulphuric acid; in some cases it will also be judicious to treat them with the iodized solution of chloride of zinc, and with nitric acid. In observing the development of pollen, it is necessary to wet the object with a solution of sugar or gum, or otherwise the appearances will be altogether changed through endosmotic action.

Beautiful sections of pollen-grains, spores, and very small seeds, may often be procured by smearing a smooth cork, on one of its flat surfaces, over with a thick solution of gum arabic, scattering the seeds or other small objects over it, and gently pressing them into the gum by the finger. Now let the mucilage dry slowly, and when dry, give it another coat, so that the small objects will be completely covered by it. In a day or two the second coating will also have become dry, when very delicate sections of the dried mucilage may be made with a hollow-sided razor. These may be placed in a drop or two of water, [which dissolves the mucilage,] and be brought under the microscope; and among the sections, some will be found sufficiently perfect for examination.

Transverse sections of the *Ovary* at various distances from each other, as well as longitudinal sections, will be found necessary, in order to examine the arrangement of the placentæ, the connection of the canal of the style with the hollow of the ovary, the position and distribution of the ovules upon the placentæ, as well as the distribution of the "vascular bundles."

The *Ovule* requires to be examined in all stages in order to understand its developmental character; and the beginner must not be disheartened by the failure of a large proportion of his sections to afford satisfactory observations. Thin longitudinal sections must be made exactly through the middle of the ovule, or, in some cases, of the ovary itself; among the many ovules which will be thus cut through, some will be found here and there to have been accurately divided; these must be separated under the simple microscope. Sometimes a transverse section will be

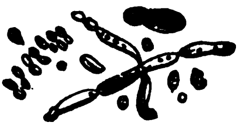
more advantageous; and some ovules of very delicate nature, small and transparent, may be examined entire. The ordinary plan is to detach the ovule, place it upon the forefinger, or between the thumb and forefinger of the left-hand, and with a very sharp razor cut it into two unequal pieces, in the direction of its axis, so as to obtain a thin longitudinal lamella. The best way of doing this is, to slice off one side of the ovule, to turn it round with a mounted needle or fine camel's hair brush, and then to slice off the other side, so as to leave a thin section, preserving all the central part of the ovule. This adheres either to the finger or to the razor, and may be freed by adding a drop of water to it; then it may be transferred to a glass slide by means of a very fine camel's hair pencil, and be examined by a low power, say a half-inch objective. It may now probably be found to require further dissection, which may be done under a simple lens, by means of very fine needles; and, sometimes, mere pressure will be of service. The correct position of the ovule upon the finger must first be ascertained by the help of a lens. For the minute details, as the existence and the number of the coats of the ovule; the position of the ovule, and especially the situation of the micropyle with regard to the hilum; the situation of the embryo-sac, and its relation to the nucleus, etc., the $\frac{1}{4}$ and $\frac{1}{8}$ inch object-glasses will be required. The contents of the cells must be tested with iodine, and the iodized solution of chloride of zinc. Ovules which have been kept in spirit will be found the easiest to dissect; when fresh, the cell-membranes are excessively delicate.

The *ripe seed* is to be formed into transverse and longitudinal sections; the form and nature of the external surface, the presence of a nucleus, of the perisperm, or of the endosperm, are to be considered, as well as the nature of the cells of the embryo itself, testing these latter with the same agents as the ovules.

The *embryo* may be divided into two equal parts, and then take a moderately thin transverse section of it. It is a good plan to soften hard seeds by soaking them in water for twenty-four hours. It will often be advantageous to detach the whole embryo, and to treat it separately from the seed. In difficult cases it must be examined on all sides with incident light under a low magnifying power, and must be illuminated in many different ways. The

parts to be examined are, the axis, the cotyledons, the plumule, and the presence or absence of albumen.

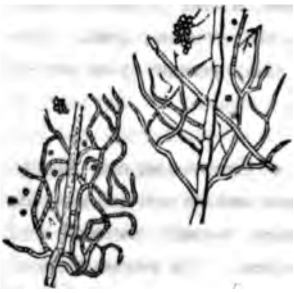
Fig. 43.



Torula Cerevisiæ.

Fungi, a class of Cryptogamous or flowerless plants, generally known by the names of mildew, mouldiness, blight, smut, dry rot, etc., also mushrooms, toadstools, puff-balls, etc. These are nearly all of a microscopic character, frequently requiring a very high power to bring them out clearly. The simplest fungi appear to be composed of one or more globular cells, as in the cells composing yeast, *Torula cerevisiæ*, *see fig.* 43. The *Penicillium glaucum*, fig. 44, is one of the most common fungi met with on decaying vegetable substances and on liquids, and is by some considered as the last term of the growth of the yeast-plant. Many animal and vegetable diseases are owing to the presence of fungoid growths, thus the *Sarcina ventriculi* has been found in the frothy fluid vomited by individuals laboring under diseased stomach. The thrush in children, ring-worm, scald-head, and other cutaneous diseases, are found to be owing to the presence of microscopic fungi; the *botrytis bassinia* destroys the silk-worm; the *botytris infestans* occasions the potato blight, as well as the tomato disease; the rust of wheat is owing to *Uredo rubigo*, and mildew to *Puccinia graminis;* the vine disease is owing to *Oidium Tuckeri;* spurred rye or ergot to *Clavicepe purpurea;* etc. etc. The character of the microscopic fungi is but imperfectly understood.

Fig. 44.



Penicillium Glaucum often met with in certain conditions of urine.

Algæ. This is a class of Thallophytes including the sea-weeds, and the multifarious green vegetable forms of simple cellular structure met with in fresh water, including the Desmidiaceæ, (Confervoid algæ,) as, Pentasterias Closterium, Scenedesmus, Micrasterias, etc. Some of these are very beautiful under the microscope. The points of interest are, their forms, their color, their multiplication by spontaneous division, and their resemblance

in many respects to animalcules; the seeds are embedded either in the frond, or in some especial receptacle, and the fronds develop cellules, in which is enclosed the reproductive nucleolus. The Desmidiæ have a horny covering, and appear, as a general rule, to contain starch as one of their constituents. Their bright green color is due to the presence of chlorophyll granules among their "cell contents." The *jointed algæ* or *confervæ*, are principally fresh-water inhabitants; they present the appearance of thread-like tubes, having joints of various lengths, their internal contents being differently arranged in different plants. These increase by a species of subdivision, by means of little granules, through which new cells or tubes are formed in succession, one after another. The Diatoms, are also a Confervoid algæ, and are usually of a yellowish or brown color. Their mode of reproduction, spores, gonidia, etc., as well as their beautiful forms and delicate markings, are all objects of much interest to the microscopist. Sea-weeds belong to a higher kind of algæ, and present more perfect forms of plants.

MOSSES, or Musci, are a low order of Cryptogamous plants, having slender thread-like stems, wholly composed of cellular tissue; their leaves are of simple structure, usually composed of a single layer of cells, and of various forms. The parts of interest to the microscopist are the leaves, the theca, antheridia, pistillidia, calyptra, teeth, operculum, sporange, spores, etc. Mosses exhibit a variety of forms of vegetative multiplication. The lower part of the stem often sends out horizontal branches, which root and produce buds, from which arise new leafy stems. They also produce confervoid filaments, which exhibit tuberous thickenings, a form of *gemmæ*, which may be detached from each other like bulbels, so as to propagate the plants without any sexual reproductive organs.

FERNS or Filices, are another class of flowerless plants, which sometimes, under favorable situations, attain an altitude of 60 or 70 feet. The most curious and interesting part of Ferns is, their reproductive organs, the thecæ or sporanges, and their spores and antheridia. These are situated on the under surface, or along the margin of the frond or leaf; when ripe the sporanges burst, and by means of an elastic ring of cells, (*annulus* or *connecticule*,)

the contained spores are scattered around to some distance. Ferns should be gathered before the capsules are quite ripe, and the sporanges be mounted as opaque objects. The development of ferns may be observed by placing the sporanges in moistened flannel, and keeping them at a warm temperature. At first a single cellule is produced, then a second; after this the first divides into two, and then the others, by which a lateral increase takes place.

LICHENS, are a class of Thallophytes between the Algæ and Fungi; they consist of simple cells united in one plane. They usually grow on rocks, bark of trees, etc., having no distinct root, stem or foliage. The points of interest in Lichens are the reproductive organs, as the apothecia, the thecæ, the spermagonia, gonidia, etc. The thallus or leaf of lichens consists of cellular tissue developed and united in various ways. This class of plants are but imperfectly understood.

HEPATICACEÆ or Liverworts are an order of Cryptogams, consisting of very small plants, varying in structure, and growing in damp spots on the ground, rocks, or trees, or floating on water; they rank between Lichens and Mosses. The frond is composed of cells containing chlorophyll, in the lowest forms; but the higher forms are more complex in structure, presenting many curious and interesting objects; stomata are found in the fronds as the plant progresses in its vegetable character. The cellular formation of the fronds, the stomata, the sporangia, archegonia, antheridia, elaters, etc., are all objects worthy of investigation under the microscope.

The *siliceous cuticles* of many plants contain the silica so arranged as to form splendid objects for polarized light, as, the Equisetum Hyemale or Dutch rush, bamboo, malacca cane, wheat, barley, oat, or rye-straw, canary seed, rattan-cane, etc. The siliceous matter may be procured by submitting any part of the stem to the flame of a blow pipe, which removes all the carbonaceous matter, leaving an ash of silica, which may be mounted in Canada balsam; or, better still, the organic part of the stem, (cut into short pieces) may be destroyed, by boiling it in nitric acid for some days, when the silica remains as a perfect cast of the

original tissue. When freed from acid by washing repeatedly with water, it may be mounted as in the former case; its true nature is best observed, however when in fluid.

Cellular tissue may be seen in sections of elder-pith, white pond-lily, pulp of orange, raspberry, or strawberry, from either of which the cells may be readily obtained; they may also be had from other plants by soaking them in water for some time, or according to Schultz's method, named under Nitric acid in the Glossary.

Fibro-cellular tissue is found in the creeper, *Cobœa scandens*, and in the leaves of some orchidaceous plants. The testa of some seeds exhibit modifications of this form of tissue.

Raphides occur in the onion, rhubarb plant, tulip, hickory, grape-vine, apple-tree, prickly-pear, etc.

CHAPTER XI.

SALIVA,—EPITHELIUM,—MUCUS,— OIL-GLOBULES,—VIBRIONES,—SPERMATOZOA,—ORGANIC GLOBULES,—PUS,—BLOOD,—CANCER-CELLS,—ITCH-INSECT, ETC.

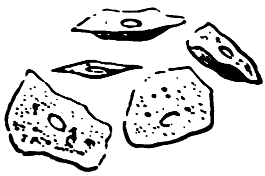
FOR a full acquaintance with the microscopic investigations of the human body in health and in disease, the reader is referred to works especially devoted to such investigations, as Hassall's Microscopic Anatomy by Van Arsdale, Jone's and Sieverking's Pathological Anatomy, Kolliker's Microscopical Anatomy, Rokitansky's Pathological Anatomy, Todd and Bowman's Physiology, etc. The points referred to at this place, will be those of more especial service to the student than to the practised microscopist.

Saliva. When healthy, the saliva has an alkaline reaction, and a specific gravity varying from 1.003 to 1.008. When expectorated it is found to contain numerous round granular cells about the $\frac{1}{2000}$th of an inch in diameter, with one or many nuclei; acetic acid renders these cells more transparent, and the nuclei more distinct. Occasionally, large oil-globules are present.

Epithelium. Epithelium is a very thin covering upon mucous tissues, and may be obtained from any mucous surface, by gently scraping it with a knife, and removing a small portion from the blade. If the addition of fluid be necessary. which will rarely be the case, a drop of water may be added, or a solution of sugar; and, if the cells are delicate, and there is danger of rupture from endosmosis, a drop or two of serum may be added. In the investigation of epithelium, the principal reagents are acetic and nitric acids, strong and weak solutions of potash and soda, and tincture of iodine. Epithelium is insoluble in alcohol, ammonia, dilute mineral acids, ether, or boiling water; generally soluble in strong acetic acid, and in strong alkaline solutions. Most forms may be preserved in the naphtha and creosote solution, see *Thwaites' liquid*, under "Preservative fluids" in Glossary, or, in a dilute solution of chromic acid.

Scaly Epithelium, or squamose epithelium, in which the epithelial cells resemble scales, may be obtained from the mouth and from the vagina. Those from the vagina are large, irregular, and often ragged cells, *See fig.* 45, varying in size from the $\frac{1}{300}$th of a line to the $\frac{1}{120}$th, and containing each, one nucleus at least. In consequence of their flattened character, they will frequently be found folded upon each other, and creased, as it were, in various directions. The trigone of the bladder presents large flattened cells, having a distinct nucleus and nucleolus, as seen in fig. 46.

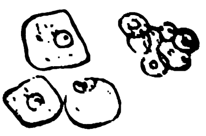
Fig. 45.



Scaly epithelium from the vagina.

Pavement or *tessellated epithelium* in which the cells lie in juxtaposition with each other, without overlapping, resembling a pavement, or mosaic work, may be procured from the epidermis of the frog; from the choroidal coat of the eye, the epithelium of serous membranes, etc. The pelvis of the kidney presents cells of this character, see fig. 47, in which the nuclei are generally well-developed and distinct.

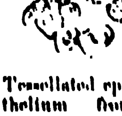
Fig. 46.



Scaly epithelium from the trigone of the bladder. A smaller variety of scaly epithelium from the bladder, is also shown n

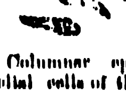
Cylindrical, *Prismatic*, or *columnar epithelium*, in which the epithelial cells are cylindrical, conical, or pyramidal, are found among the intestinal villii, the epithelium of the ureters, urethra, and gall-bladder. Fig. 48, is a delineation of the cells of the urethra. In the fundus of the bladder, columnar epithelial cells are found, together with large oval cells, as seen in *fig.* 49. They appear to line the mucous follicles, while the scaly epithelium lies on the surface of the mucous membrane between them, see *fig.* 46. In the ureters, the columnar form of epithelium is very abundant, with large and distinct nuclei, as in fig. 50.

Fig. 47.



Tessellated epithelium from the pelvis of the kidney.

Fig. 48.



Columnar epithelial cells of the urethra

Glandular or *spheroidal epithelium*, in which the cells are more or less rounded, although, in many instances, from mutual pressure, they become polyhedral. This form of epithelium takes part in the process of secretion in most glandular organs. It is met with in the sweat glands, in the

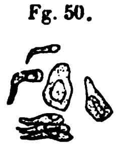
Fig. 49.

Columnar epithelium from the fundus of the bladder.

secreting tubes of the stomach, in the convoluted portion of the tubes of the kidney, *see fig.* 51, etc. The nucleus is generally well-developed, and frequently surrounded by numerous minute granules, and occasionally small oil-globules.

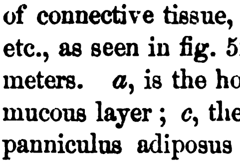
Ciliated epithelium consists of the columnar kind with cilia attached; sometimes the cells are small and of nearly the same length and breadth. It may be procured from the back part of a frog's mouth, or from the branchiæ of an oyster or mussel; the cells must be moistened with some of the mucus taken from the same surface, or, with some of the juice from the animal, or, with a little clear serum. In examining ciliary movement, it is often advantageous to place the smallest quantity of lamp-black or carmine with the cells, so that the direction of the current produced by the cilia can be clearly demonstrated by the movement communicated to the insoluble particles. If water be added the movement soon stops, in consequence of endosmosis taking place.

Fg. 50.



Columnar epithelium from the ureters.

Fig. 51.



Glandular epithelium from the kidneys.

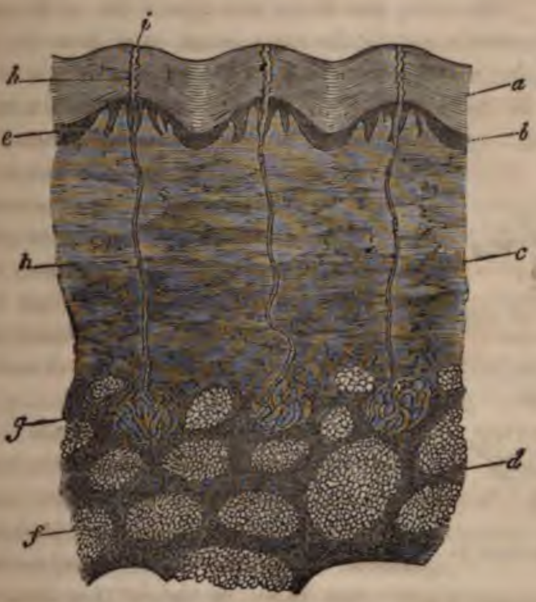
In man, ciliated epithelium may be obtained from the mucous membrane of the nose and its sinuses, on the upper and posterior part of the soft palate, on the os uteri, within the cavity of the uterus, on the mucous membrane of the larynx, trachea, and bronchial tubes, etc.

The external skin consists of an internal layer formed principally of connective tissue, and rich in vessels and nerves, the true skin, etc., as seen in fig. 52, in which the skin is magnified twenty diameters. *a*, is the horny layer of the epidermis or scarf-skin; *b* its mucous layer; *c*, the corium or true skin; *d*, upper part of the panniculus adiposus or cellular membrane beneath the skin; *e*, papillæ of the true skin; *f*, masses of fat; *g*, sweat glands, of which three are seen; *h*, canals of the sweat glands; *i*, pores of the sweat glands on the surface of the skin. The section of skin represented in fig. 52 is taken from the ball of the thumb, but when taken from other parts of the body covered with more or less hair, hair-follicles will also be seen.

Mucus corpuscles consist of delicate granular cells, rather larger than blood globules, which they somewhat resemble. They

occur in all healthy mucus, being more numerous in irritated conditions of the mucous membranes. They are insoluble in alcohol and acids, but soluble in solution of potash. Healthy urine on standing for some hours deposits mucus in the

Fig. 52.



form of a bulky, flocculent, transparent cloud; if this be examined under the microscope, it will be found to present the appearance shown in fig. 53. A very thick, glairy, gelatinous deposit, which is frequently found in the urine in cases of disease of the bladder, must not be mistaken for mucus; this consists of pus altered by the action of carbonate of ammonia which has been set free in consequence of the decomposition of the urea by the mucus or some other animal matter acting upon it as a ferment, after it has left the bladder—in these cases an ammoniacal odor is evolved from the urine. When mucus globules are acted upon by acetic acid the granules disappear, and they present the appearance shown in fig. 54.

Fig. 53.

Mucus in urine, with a large epithelial cell from bladder and nucleus.

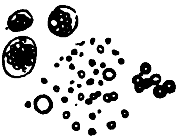
Cells containing *fatty matter* or *oil-globules* are sometimes met with in urine, and other fluids. The cells as well as the isolated oil-globules are shown in fig. 55. The peculiar character of the oil-globules have already been described on page 63. When in the urine they are indications of fatty degeneration of some of the urinary tissues.

Fig. 54.

Mucus after having been acted on by acetic acid.

Vibriones, are frequently met with in the urine, of cachectic and debilitated persons, as well as of those laboring under some disease of the bladder or urethra. They are seen as minute lines under the microscope, with active, oscillating or twisting movements, and are frequently developed in the urine before it has left the urine. They always exist in decomposing urine. The commonest forms are shown in fig. 56.

Fig. 55.



Oil globules, and cells containing them.

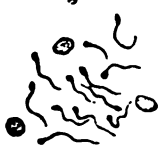
Spermatozoa, or seminal animalcules, are more or less oval in form, and are furnished with long and delicate tails. In their native fluid they move about actively, but when in urine they soon become destroyed, hence, to find them in urine, this should be examined as soon as possible after it has been passed. The occasional presence of spermatozoa in urine is consistent with perfect health, and must not be looked upon as a symptom of spermatorrhea; when they are constantly present, and are accompanied with other more important symptoms, we may suspect this condition. Seminal urine contains a few oval, minute, granular corpuscles, called spermatic granules. *See fig.* 57.

Fig. 56.

Vibriones, found in urine.

Spermatozoa may be best examined and preserved by washing them with distilled water, and drying them upon a slide.

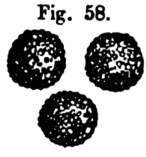
Fig. 57.



Spermatozoa, and seminal granules.

Large organic globules, fig. 58, are occasionally found in urine, especially in cases of scalding of urine, and in the urine of pregnant women, especially during the latter months of pregnancy. They are allied to mucus, are much larger than either the pus or mucus globules, and consist of a granular membrane investing a series of transparent nuclei which become visible on the addition of acetic acid. They float freely in the urine, seldom forming a deposit, and unlike pus or mucus in urine, are not

Fig. 58.

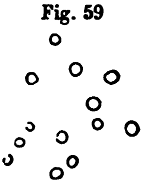


Large organic globules.

accompanied by albuminous and viscid fluids. In confirmed Bright's disease of the kidneys, they occur in abundance.

Small organic globules, are more rarely met with. They are smaller than the pus or mucous corpuscles, spherical, smooth on the surface, and destitute of granulation or a nucleus; they roll over each other when shaken, and are not affected by acetic acid. *See fig.* 59.

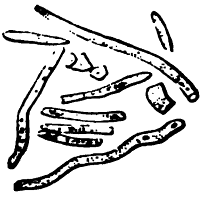
Fig. 59



Small organic globules

The urine in Bright's disease is always albuminous, and usually contains epithelial cells, mucus and blood-corpuscles, saline sediments, fibrinous casts of the uriniferous tubes, or *coagulated albumen* presenting a tubular vermicular appearance as shown in fig. 60, seldom larger than $\frac{1}{50}$th or $\frac{1}{100}$th of an inch, and their diameter never exceeding $\frac{1}{1000}$th of an inch.

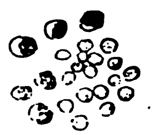
Fig. 60.



Coagulated albumen in Brights' disease.

Pus is met with in various fluids of the body, being generally secreted from ulcers, or parts where decomposition is going on. It is a thick, yellowish fluid, consisting of serum, and pus-corpuscles; the serum is clear, colorless or yellowish, has a feeble alkaline reaction, and coagulates on being heated; it contains considerable albumen. The pus corpuscles are oval or spherical, smooth, even, and transparent, or granulated, opaque and nucleated, measuring about the $\frac{1}{1000}$th of an inch in diameter. *See fig.* 61. It is frequently difficult to determine pus from mucus-corpuscles. Those of pus are destroyed by caustic alkali, and converted into a thick glairy mass, which cannot be poured from the vessel containing it in drops. Water containing a trace of iodine in solution causes the pus-globule to swell, and displays the central mass. But the best reagent is acetic acid, which, if not very strong, causes the corpuscle to swell to nearly double its original size, and renders its outline more clear and distinct, at the same time developing in its center one or more little bodies, insoluble in ether, as in fig. 62.

Fig 61.



Pus-globules.

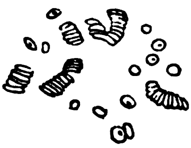
Fig 62.

Pus globules acted on by acetic acid.

Blood. When a drop of blood is placed upon a glass slide, covered with thin glass, and placed under the micro-

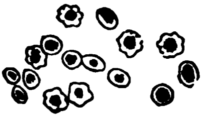
scope, it will be found to contain red and white globules, and globulin. The red globules are circular, flattened, biconcave bodies, being thinner in the center than at the edges, and presenting consequently an apparent but not real nucleus; when seen by reflected light, they are red; when by transmitted, they are yellowish. *See fig.* 63 and 64. They are about the $\frac{1}{5000}$th of an inch in diameter, and have a tendency to turn upon their edges, and to arrange themselves into rolls like roleaux of coin. The white globules are much less numerous, and of larger diameter than the red, being about $\frac{1}{2000}$th of an inch in diameter, are round, not colored, and have no central nucleus, but contain granulations on their surface. Acetic acid, not too strong, renders the external cell-wall of the colorless corpuscles very transparent and also brings the nucleus into view, consisting of one or two round granules.

Fig. 63.



Blood corpuscles cohering.

Fig. 64.

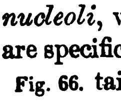


Blood corpuscles separate.

When it is desirable to discover whether a certain stain consists of blood, it must first be moistened with the white of egg, then scraped off the material holding it, and examined under the microscope with a quarter of an inch object-glass. If the stain consists of blood, blood-corpuscles will be rendered distinctly visible.

Cancer-cells, should be studied under a power of at least 500 diameters, with a clear definition. A drop of the matter of cancer may be placed on a glass-slide and covered with a thin glass, or, the cut surface of the tumor may be scraped with a scalpel, a little water be added to it, and then placed on the slide, as above, for examination. The nuclei of cancer-cells will be found enclosed in the cell, or floating free, usually more or less of both. The characters of the matter of cancer is as follows; 1. the *nuclei* with the *nucleoli*, which are very brilliant in the center; these nuclei alone are specific (*See fig.* 65) they are exactly similar to those contained in the cells. They usually contain one or two nucleoli, but there may be three.

Fg. 65.



Free cancer nuclei.

Fig. 66.

Small cancer cells.

The cells vary very much in their appearance, they may be small and regular, as in fig. 66, or they may be large and regular, as in fig. 67, or present different singular forms, as seen in figs. 68, 69, and 70. When cells are found

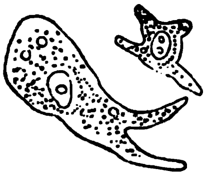
containing one or more nucleate cells, they are called mother cells. *See figs.* 71 *and* 72.

Fig. 67.

Large cancer-cell, regular.

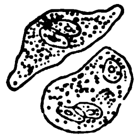
The itch is produced by an insect called *Acarus Scabiei* or *Sarcoptes Hominis*. It varies from $\frac{1}{77}$th of an inch to $\frac{1}{147}$th in length, and from $\frac{1}{84}$th to $\frac{1}{203}$d of an inch in breadth. It is a minute whitish creature having no true

Fig. 68.



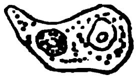
Irregular and bifurcated cells, the most usual forms.

Fig. 69.



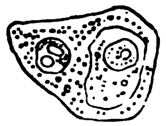
Cells containing double nuclei, frequently seen in cancer of the bladder.

Fig. 70.



A cell with two nuclei.

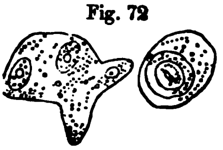
Fig. 71



A mother cell containing a simple nucleus, and a nucleated cell.

head, but is provided anteriorly with proboscis-like mandibular organs furnished with four bristles. There are eight legs, four anterior are inserted into the thorax by the side of the proboscis; they are jointed, and furnished with hairs and bristles, the last joint of each, terminating in an adherent disk. The posterior legs without adherent disks, terminate in very long bristles. The animal burrows in the epidermis and forms minute channels, at the end of which it may often be discovered; it does not inhabit the vesicles or pustules which constitute the eruption, and are simply excited by the irritative proceedings of the animal. *See fig.* 73.

Fig. 72

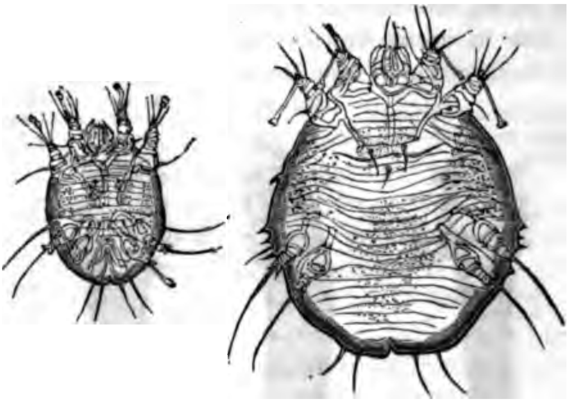


Mother cells, containing two, three, or more nuclei.

With a bright light, and a good pair of eyes, a small spot or streak will be observed upon some part of the affected surface, at an early part of the disease; this is the original opening made by the insect on entering the skin, and from this spot will be traced a whitish streak or line of a few lines in length, which is the burrow of the acarus, and at its termination the insect will be found,—there will be a slight elevation over it, beneath which the insect

will be seen as a greyish speck; it can readily be removed by carefully raising the skin with the point of a needle, exposing it to view. It must be recollected that the primitive vesicles only, and which are produced by the entrance of the insect, will represent the above white streak; the insect is never found within a vesicle or pustule. They are most easily found by examining the skin with a power of 50 to 70 diameters, attached to a firm but moveable arm, and with the aid of a good bull's eye condenser.

Fig. 73.



Male (smallest) and Female Itch Insect, magnified 100 diameters.

The entire animal may be preserved in glycerine, or solution of chloride of calcium; the parts of the mouth should be dried and mounted in Canada balsam.

Another disease of the skin, known as *comedones*, *grubs*, or *worms in the skin*, is owing to an insect called the *Acarus*, *Steatozoon*, or *Demodex folliculorum*. It is more commonly observed on the face, especially the nose, presenting the appearance of round, black spots, which are more or less thickly clustered together, and which, when the skin, including one of these spots, is pressed between the fingers, discharges the concrete substance in the form of a minute white cylinder with one of its extremities blackened. A drop of oil should then be added to the secretion, and the whole allowed to macerate for some hours at a gentle heat. Or, the secretion may be digested in a mixture of alcohol and ether, to dissolve the fatty matter, and then treated with solution of potash. The secretion contains the ova, the young animals, and the exuviæ.

This insect, *see fig.* 74, is from $\frac{1}{72}$th to $\frac{1}{125}$th of an inch long, and about $\frac{1}{500}$th of an inch broad; it has an elongated figure, a long thorax with four pairs of short, conical legs, and an abdomen three times as long as the thorax, which gradually tapers to an obtusely pointed extremity. The head is continuous directly with the thorax, and has two large palpi, and a proboscis situated between them. The abdomen is marked by a number of transverse lines or grooves, and contains round, oval and quadrate transparent places among granules; the legs are terminated each by three claws, one of which is longer than the other. The insect is slow in its mövements but retains, its vitality for some time after being removed from the skin.

Fig. 74.

Steatozoon Folliculorum, seen upon its abdomen, back, and side.

The advantages to be gained by a knowledge of the microscopic appearances of the various parts of the human body as well as of the bodies of the different animals, are very great, and this branch of science has already acquired a very important consideration in medico-legal investigations, those engaged in them receiving very high fees.

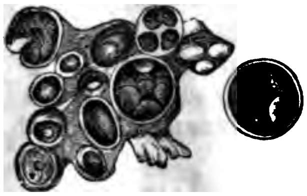
In cases of murder, the stains on a weapon, clothing, or elsewhere, can positively be determined to be human blood, animal blood, or no blood at all; the minute filaments on a weapon can be detected either as human hair, hair of some animal, or the fibers of cotton, silk, or wool; and other, almost unobservable

specks can be distinguished either as human skin, or some other known or unknown substance; thus settling at once, in many instances, the question whether murder has been committed.

In cases of supposed violation, the presence of spermatozoa in the stains on the clothing, will verify the suspicions which have been excited. And so in many other instances of supposed criminality, the microscopic examination of objects in some way connected with the circumstances, and which objects are almost, if not quite invisible to the naked eye, will solve all doubts.

Fig. 75 is a representation of some calcareous particles which have been found in the lungs, and other parts of the system, by Drs. Alvord, Thompson, Quain, Bennett, Gleege, Lebert and Wagner, etc.

Fig. 75.



CHAPTER XII.

URINARY DEPOSITS AND CALCULI.

The examination of urinary deposits under the microscope, has within a few years past become a subject of great importance, assisting physicians to form a correct diagnosis in many cases of disease. It is not the province of the present work to enter into an exact description of the several deposits met with in the urine, nor their causes; but it may be of service to those into whose hands the work may fall, to have some idea of the mode of collecting such deposits, and their ordinary appearances, so as to be enabled to determine them from each other, when under observation.

Urine should be examined immediately after it has been passed; in about from three to six hours afterward; and again, after it has been allowed to stand for twenty-four hours. Some urine is passed in a state of decomposition; other specimens may decompose within a few hours after its excretion; and, again, it may not decompose for many hours. The urine should be placed in a long cylindrical glass vessel, or in a test tube, and as soon as a deposit is observed, a portion of it must be taken up by a pipette, and deposited on a glass slide for examination. The quarter inch objective will answer for most of the deposits—spermatozoa will require an eighth.

Fig. 76.

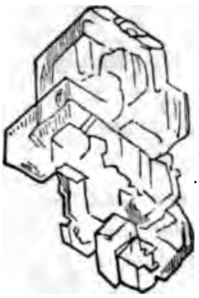
Evaporated residue of healthy urine.

When a few drops of healthy urine are slowly evaporated on a glass slide, an appearance is presented like that of fig. 76.

Urea is one of the principal ingredients of urine, and appears to be the vehicle through which a large quantity of the nitrogen of the exhausted tissues of the

body is removed from the system; it constitutes about the one seventieth part of the urine, sometimes a little more, at others, less. When urine is concentrated to about one half its bulk, and then mixed with an equal quantity of pure nitric acid, a drop of this on a glass slide will, as the fluid evaporates, form delicate, crystalline, rhomboidal plates of nitrate of urea, *see fig.* 77. If urea, however, be present to excess, a drop of the urine may be treated with a drop of nitric acid, without concentration, and evaporated in the cold; the nitrate of urea will form in abundant crystals.

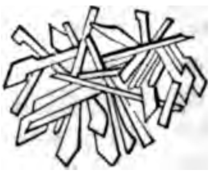
Fig. 77.



Nitrate of urea.

If urine be concentrated to about one eighth its bulk, and filtered through muslin to separate the insoluble deposit of phosphates and urates, and then be mixed with an equal bulk of a strong solution of oxalic acid in hot water, the mixture, on cooling, will deposit an abundant crop of crystals. Press these between folds of bibulous paper, then wash them with a small quantity of ice-cold water, and purify by recrystalization, removing, if necessary, the last traces of coloring matter by boiling the solution with animal charcoal,—colorless, tabular or prismatic crystals of oxalate of urea will be obtained as represented by fig. 78.

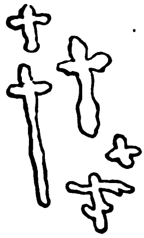
Fig. 78.



Oxalate of urea.

Urine frequently contains chloride of sodium in combination with urea, which may be known by the croslets and dagger-like crystals formed when the urine is quickly evaporated, as in fig. 79. Chloride of sodium, when crystalized from distilled water, forms crystals somewhat resembling those of oxalate of lime, as in fig. 80. But they differ from this salt in being soluble, and never found in urine. But there is a form of crystalization of chloride of sodium from urine, which much resembles the crystals of oxalate of lime, differing from them, however, by being soluble in water; they are shown in fig. 81. These crystals form when evaporation proceeds very slowly. Chloride of sodium also crystalizes in forms somewhat resembling those of Cystine, especially when the urine is slowly evaporated, but they may be determined from

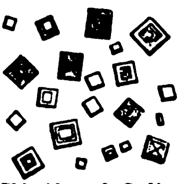
Fig. 79.



Chloride of Sodium with urea.

cystine by their greater solubility in water, and by disappearing when the urine is heated; fig. 82 gives a representation of them.

Fig. 80.



Chloride of Sodium from distilled water.

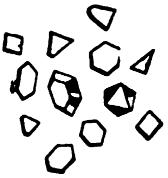
The following cuts in the remainder of this Chapter, and throughout the next, represent the various other forms of deposit found in both healthy and unhealthy urine; and as they likewise enter into the composition of calculi or stone in the bladder, I have for brevity and easy reference, placed them in the order in which they will be found. The balance of this Chapter and the whole of the next I have translated from a pamphlet in French, published at Paris, and entitled "Researches on Vesical Calculi, and their Micro-Chemical Analysis," by Samuel L. Bigelow, M. D.; it will be found to contain much useful information both to the medical student, and practitioner, as well as to the general reader.

Fig. 81.

Chloride of sodium crystalized slowly from urine.

Vesical calculi have been variously classified. The classification which has been more commonly received is that which is based upon their combustibility or non-combustibility, or rather on the changes in their aspect and composition when exposed to the action of heat. Now, as there are three different results, when thus exposed, they have been arranged in three classes, according to these three modifications:

Fig. 82.



Chloride of Sodium resembling cystine.

FIRST. The combustible calculi, which completely disappear under the action of a sufficient degree of heat.

SECOND. Incombustible calculi, which are not dissipated by the action of heat.

THIRD. Calculi which are partly combustible, leaving more or less considerable residue.

In the first class are placed the following substances:—

1st. Uric acid.

2nd. Uric oxide.

3rd. Cystine.

4th. The combinations of these three substances with each other, or with another combustible matter, such as ammonia.

In the second class;—

1st. The phosphates.

2nd. The carbonates.

3rd. Silica.

4th. Mixtures of these three substances.

In the third class are ;—

1st. Compound calculi, formed by the combination of the kinds contained in the two preceding classes, of which, after the action of heat, the residue consists :—

1st. Of phosphates.

2nd. Of carbonates, or caustic bases.

3rd. Of phosphates with NO. 2 ; and,

4th. Of accidental ingredients, etc.

I consider this not only a very arbitrary classification, but entirely useless so far as the analysis of calculi is concerned. With the same justice, they could have been classified according to the action of water, acids, or other chemical agents upon them. In accurate analyses, heat as with these, is a means, but not an only one. Their analysis is always commenced by submitting them to heat, to ascertain their organic character. But after its action, the chemical nature of the remaining substances is no more understood than previously. It is absolutely necessary to have recourse to the same analytical tests which would have been required before submitting them to the action of heat; burning them would be lost time, if it were not to determine the exact per cent. of loss. I speak of clinic qualitative analysis and not quantitative. With a little experience in the analysis of calculi, we learn to classify them with sufficient accuracy, by the sight alone, except in some very rare instances.

There is, however, a natural classification which I have adopted, determined by the composition of a calculus and verified by analysis, and which arranges them into three very distinct categories :—

FIRST. Organic calculi.

SECOND. Inorganic calculi.

THIRD. Calculi composed of these first two, with mediate and immediate principles.

Uric Acid—Chemical Pathology.—When uric acid exists in a urinary deposit uncombined with a base, it is always in crystaline form, and never as an amorphous mass ; but the crystals are too small for investigation without the aid of a microscope. Uric acid is never deposited colorless in urine, even when combined

with the urate of ammonia. It more frequently presents a characteristic yellow color. On the contrary, when precipitated from a solution in water it is generally colorless, and very rarely of a yellow tinge.

In urine it may present all shades, from the palest straw color to the deepest orange, in consequence of which, these deposits have been termed red or yellow, or lateritious sediments, and this color, which is their proper characteristic, is preserved in the crystals invisible to the unaided eye, as well as in the calculi of various sizes.

Diagnosis of Uric Acid Deposits. Under a gentle heat, the deposit of uric acid is not dissolved; the crystals only become a little more opaque. They become clearer when combined with urate of ammonia, which is dissolved by a heat slightly above that of the urine in the bladder, and which had previously kept them concealed. The best plan to discover them when the urine is clouded by urate of ammonia, is to heat a little of the urine in a watch glass; as soon as the urine is dissolved, the uric acid crystals will be visible in the bottom of the glass.

Heated with potassa, uric acid is dissolved and forms urate of potassa which is readily soluble in the alkaline solution; it is not acted upon by hydrochloric or acetic acids, but dissolves readily in nitric acid, and this solution carefully evaporated to dryness leaves a fine scarlet colored residue, which, when exposed to the vapor of ammonia, assumes a rich purple tint. [And on moistening this with a little caustic potassa, a splendid violet tint is developed.] This residue is the *murexide* of Liebig, or the *purpurate of ammonia* of Prout. Urine depositing uric acid always turns blue litmus paper red, as well as its solution in water; it frequently holds an excess of urea, which causes a slow crystallization when nitric acid is added. In general, the deeper the color of the urine, the deeper is the color of the uric acid deposit; its specific gravity is commonly above 1.020; the pale urine of infants at the breast, in which this deposit is very common, is an exception to this rule.

The deposit often occurs as a dark-yellow crystaline precipitate, and at the same time the supernatant urine is pale like water, being only 1.006 sp. gr. This fact is explained by the small proportion of alkaline phosphates which exists in the urine of infants.

Chemico-Physical Properties of Calculi composed of Uric

Acid. They are yellowish or reddish-yellow, especially when they are moist; when divided by a saw, they give a powder similar to the sawdust of wood, which evolves an odor of hydrocyanic acid when gradually heated in an open vessel; on elevating the temperature to a red heat it burns without residue; it does not evolve ammonia with the alkalies, but by trituration with the strong alkalies, it forms unctuous compounds, and readily dissolves in those which are diluted, or in excess; from which it is precipitated in white flakes by acids, which, when collected upon a filter, soon appear like brilliant spangles. It is decomposed by nitric acid, leaving a red residue on evaporating the solution to dryness. Pure uric acid forms small crystaline plates, soft to the touch, inodorous, tasteless, readily reddening litmus paper, and which combines with all the bases. The existence of uric acid in a stone, the same as in urine, is recognized by its solubility in nitric acid, which solution when evaporated in contact with ammoniacal vapor, forms a purplish-red mass, (which changes to violet on the addition of a little caustic potassa).

Urate of Ammonia. Urate of ammonia very rarely forms calculi unless combined with other substances; however, it is more frequently found as a part of them than any other urate; in nearly one half of our analyses it has been met with, very seldom as a principal constituent, but often in considerable quantity. When it forms a calculus, or a layer, it is of an ashy-grey color, burns without residue, evolves a strong ammoniacal odor with alkaline solutions, beside acting with these solutions in a manner similar to that of uric acid; it is always with an excess of acid; it presents the same phenomena with nitric acid; it is more soluble in water than the urates of the fixed alkalies, and its peculiar properties render it easily distinguishable from them; for instance, the urates of potassa, and soda, leave a residue after the action of the heat.

Urate of Magnesia. Although urate of magnesia seldom constitutes an essential material in the composition of a stone, yet its scarcity, even in considerable quantity, has been much exaggerated by writers. Among 157 analyses, I have found it 27 times, or nearly $\frac{1}{6}$th, and among others, once as the exclusive material of a very large stone. with the exception of traces of phosphate; I have often met with it in considerable quantity. Next to urate of ammonia, the urate of magnesia is found the oftenest

in vesical calculi, and, notwithstanding what has been said, it is much less soluble in water than the former; consequently the reason which has been given to account for its great infrequency among calculi, to-wit, its greater solubility, is incorrect.

Urate of Lime. This urate is much less soluble in water than all the others; it is never found in large quantity among calculi, nor free in the urine in crystalline form; it is sometimes found in combination with oxalate of lime, rarely with the fusible elements; but more frequently, when it is present, it is in combination and in trace only with the other urates, and the phosphate of lime.

Urate of Potassa. This salt is free from combination with other salts, is soluble in nearly 400 times its weight of cold water, and much more soluble in hot water; by the addition of a little caustic potassa, it becomes readily soluble in a small quantity of water. On account of its great solubility, this urate very rarely enters into the composition of a calculus, and always in minute quantity.

Urate of Soda. This salt makes a part of urinary calculi; however, it is rarely found in any great quantity, although it forms the principal material in gouty concretions. In many of its properties, it resembles the urate of potassa.

Cystine. These calculi are very rare; there is only one in the collection of Dupuytren's museum. They are formed by an organic substance which is readily recognized by its chemical properties. Cystine is obtained in a state of purity by dissolving the powdered cystic calculi in ammonia, filtering the solution, and then evaporating. The cystine separates in minute crystals which retain no ammonia; its composition corresponds to the formula $C^6 H^6 NS^2 O^4$. It is a light straw colored substance, crystalline, inodorous, insoluble in water or alcohol, but readily soluble in ammonia. It forms a weak base with acids, being easily dissolved by them, but forming no permanent combinations. It may be viewed as a feeble organic alkali. Thrown on burning charcoal, it evolves a garlicky odor, similar to that exhaled by arsenious acid; sulphur has been found in it.

Xanthic or Uric Oxide. M. Marcet, in a great number of analyses of calculi which he has made, met with a new body of an animal nature, which, from its behavior with nitric acid, forming a permanent yellow mass on evaporation not reddened by ammonia, he proposed to call xanthic oxide calculus. But as

M. Marcet has observed this body only once, and has acknowledged that it might have been an accidental production; and as I have not found it once during several hundred analyses, I will not describe it, but refer those who desire to know it to the memoir of the author. (Stromeyer has since found it once in a large stone taken from a child; it occurs as a white powder, forming when dried, pale, yellowish, hard masses, when rubbed resembling wax, slightly soluble in water, soluble in caustic alkalies but precipitated by carbonic acid, insoluble in alcohol, ether, and oxalic, or hydrochloric acids, and, exposed to heat, it decomposes without fusion, evolving at the same time hydrocyanic acid, with a peculiar odor.)

Animal Substances beside Cystine, Uric Oxides, and Fibrinous Matter. These substances have not yet been isolated; they exist in nearly all vesical calculi especially in those of oxalate of lime, which they color brown, and all the parts of which they hold together. They probably consist of altered mucus, epithelium from the mucous membrane of the bladder, of blood, and of the coloring matter of urine.

Oxalate of Lime Calculi. Oxalate of lime calculi are gray, and more frequently of a deep brown color, probably, in consequence of the animal matters which accompany them, nearly always disposed in undulating layers, presenting on their surfaces, tubercles, seldom acute, more often rounded, similar to those of mulberries, giving when they are calcined, a white, slate-colored residue, easy to recognize by this prominent and constant slate color; the lime is known by its acrid taste, and the carbonate of lime by its effervescence with acids. When this residue is composed only of lime, it amounts to very near one third of the calculus by weight; it is soluble in concentrated hydrochloric acid, which it colors deep brown, the color of the solution resembling somewhat that of the tincture of muriate of iron. This phenomenon is probably owing to the presence of a large amount of animal matter in oxalate of lime calculi, which agglutinates the particles closely together, giving the compact, smooth, non-crystalline appearance, which these calculi generally present. I have met with it once in the museum of Dupuytren, containing very little animal coloring matter, presenting all the characters of a crystalline calculus, and which we could see was composed of large, white crystals, presented, so to speak, upon a thin layer slightly

tinged with animal coloring matter. This kind is exceedingly rare; I have never seen a description of it, and have met with it once. The oxalate of lime which composes these calculi is nearly pure.

Double Phosphate or Ammonio-Magnesian Calculi. Calculi of double phosphate are white, crystalline, translucent, vitrifiable by a red heat under the blowpipe, they emit ammoniacal vapor when triturated with alkalies, and are not dissolved by them. They dissolve very readily in acetic, hydrochloric, sulphuric, etc. acids.

Phosphate of Lime Calculi. These are white, opaque, non-crystalline, non-vitrifiable, lose hardly anything by calcination, do not evolve ammonia when triturated with the alkalies, in which they are insoluble, forming with them a thick magma with evolution of heat, and are soluble in acids, but less readily than the ammonio-magnesian phosphate.

Silica. Silica is seldom met with in vesical calculi, even in trace. I have not found it in any of my analyses, although having very carefully sought for it; in a stone in Dupuytren's museum, or in an anterior analysis, it is said to have been found in some quantity. It has been described as presenting the same aspect as oxalate of lime, but is less colored; it is easily distinguished by losing nothing on calcination, the residue being insipid, not acted upon by acids, and vitrifiable by alkalies. It has never been found isolated, except once, by M. Lassaigne, in the urethra of a sheep.

CHAPTER XIII.

MICRO-CHEMICAL ANALYSIS OF VESICAL CALCULI.

THE analysis of vesical calculi, as with all other chemical analyses, presents two problems for solution, that of *quantity* and that of *quality*. The chemist who thoroughly investigates, who makes discoveries, is obliged to resort to quantitative analysis; while qualitative analysis combined with a proximate quantitative, will answer for the physiologist. After having determined the presence of a urate in a stone, and its proximate proportion compared with the other substances entering into its formation, what necessity is there for the physiologist to know the exact proportion of the organic material, and of the base which was required to form the urate in question? These are to be ascertained by the chemist, upon whom we must rely. I will, therefore, present only qualitative, with proximate quantitative formulæ.

Hitherto, the chemist alone has been able to determine the composition of calculi; physicians have been obliged to place them in his hands for examination, and await his decision. There are, however, many instances in which the physician ought to know the composition of a small gravel, or of a piece of stone, in order that he may at once determine upon the proper treatment to be pursued. And for this purpose, he should have some simple process to enable him to arrive at such knowledge, without being himself a chemist. I will, therefore, briefly describe the processes which I believe will answer the purpose, viz., the conjunction of the microscope with chemistry,—processes which are very simple, and which may be learned in a very short time by physicians accustomed to using the microscope. Many chemical reactions may be learned, and many precipitates recognized, without one being an actual chemist.

Chemistry is so extensive a science, that the physiologist, the manufacturer, the artist, etc., find it indispensable to aid themselves

by culling from some portions of it. To each speciality, it has an application that completely isolates it from the science, becoming thus accessible to the various professions to which it may present the desired facts and information.

Although I constantly use the microscope in the analysis of calculi, I believe it will be better to devote one chapter particularly to the chemical proceedings, before treating upon the microscope, which will be referred to in a subsequent chapter. This course will prevent the mind from becoming confused, which is apt to occur when too many things are crowded together. In our analysis, we will proceed as follows:

We divide the stone into three portions, A, B, & C, and act on each of these separately. The one, A, will serve to determine, in a general manner, the nature of the organic, inorganic, or mixed calculus, as well as of the bases which may be combined with the organic substances. The other, B, is designed for the separation of those matters which are soluble in acids. The third C, is for the purpose of ascertaining the principles which are soluble in water only, without being decomposed.

Portion **A.** We take a small portion of the stone, and reduce it to powder; this is weighed, placed in a platinum capsule, and submitted to the action of an elevated heat, (by blowpipe, or otherwise.) If the heat dissipates all of it, it is proof that the stone is composed of organic substances, perhaps uric acid, urate of ammonia, or creatine, etc. If a residuum is left, it must be weighed anew, to ascertain the per centage of loss by heat; after which, it must be chemically examined to determine its character. If the consumed part consists wholly or partly of uric acid, either pure or combined with earthy bases, we may determine it, by warming a portion of the original substance, (A) on a platinum spatula, with a little nitric acid; a few drops of ammonia, may now be added to neutralize the acid, and then gradually evaporate to dryness. If this portion contains the least trace of uric acid, or of a urate, these acids become changed into purpuric acid, which is readily known by its beautiful red or purple color, more or less dark, according to the amount of these substances which may be present.

By this simple process, together with a small share of experience in the analysis of calculi, we may almost guess their entire composition; but strictly, this will so far satisfy us, as it reveals

the class to which the calculus belongs, and we may then pursue all the analytical steps necessary, to determine more particularly, the substances of which it is composed, and which I now proceed to explain.

Portion B. This portion must be bruised in an agate mortar, and be reduced to an exceedingly fine powder; place this in a platinum capsule, (or a glass test tube,) add to it a little concentrated hydrochloric acid, and boil it, for the stone may contain oxalate of lime, which is soluble only in boiling hydrochloric acid. The other substances, as the carbonate, and the phosphate of lime, as well as the ammonio-magnesian phosphate, are soluble in cold hydrochloric acid; the carbonate and the double phosphate are very soluble in acetic acid; but it is better that they all enter into the same solution.

The above solution must be filtered, to remove any organic substances it may contain, as animal matter and uric acid, which may have originally existed pure in the stone, or which may have been precipitated under this form, by the decomposition of the urates acted on by the hydrochloric acid, which acid dissolves the earthy bases, and precipitates pure uric acid, which is insoluble in the mineral acid. At this period of the analysis, it is unnecessary to examine the filtrate, as the third portion, C, is designed to determine these organic matters; we filter to remove them from the solution, which we then dilute with distilled water.

We now reach that part of the analysis which may, at first, appear complex and difficult, but a little experience will remove this idea. The object is, to determine and separate the substances contained in the solution before us. When we know the course proper to pursue to analyse one calculus, we will be able to analyse all inorganic or mixed calculi, for the same course is to be followed.

At first, we will enquire what substances may be contained in the solution? We know that they may be some of the following; oxalate of lime, phosphate of lime, carbonate of lime which will be changed to chloride of lime, ammonio-magnesian phosphate, and the bases of the urates which have been decomposed by the hydrochloric-acid, as soda, potassa, magnesia, etc. It may contain all these materials together, or only a single salt, as the oxalate of lime, and, in this case, the solution will be of a very deep color, of the characteristic brown, caused by the animal coloring

matters which these calculi hold in considerable quantity. If it be the carbonate, there will be an effervescence in the solution, owing to the disengagement of carbonic acid gas upon the addition of the hydrochloric acid. The substance may be phosphate of lime, alone, or combined with the double phosphate, or *vice versa*, and in this case, the solution will be hardly discolored; or finally, one of these substances, which form the greater part, may be combined with traces, or more or less considerable quantities of a part, or even of all the other materials. We can, therefore, perceive the necessity, not only of verifying the presence of such or such a body, but likewise, the presence or absence of all the others, whatever may be their proportions. Then having reached this point, we must pursue the same course for all vesical calculi, and which is as follows:—

1st. Gradually add ammonia to the solution, being careful to cease as soon as the acid is neutralized, which may be known by a cloudy appearance in the liquid, occasioned by the formation of crystals which will soon be precipitated; or, we may place a piece of reddened litmus paper in the solution, which will be changed to blue as soon as the liquor becomes a little alkaline.

The precaution to gradually drop the ammonia is very important, because if it be rapidly poured, and in excess, crystallization will not have time to be realized; the oxalate of lime will fall in an amorphous mass, without regular form, and the double phosphate, although it takes a well known crystalline form, will not assume its characteristic figure.

When the acid is neutralized, the crystals are precipitated together, (for we are supposing a complex calculus), the oxalate of lime, the phosphate of lime, and the ammonio-magnesian phosphate; the carbonate of lime becomes changed into a chloride of lime, and remains in solution. It is unnecessary to attend to the bases of the urates, such as soda, potassa, etc., because we have the remaining portion C, which will furnish us with the organic substances.

2d. To verify the presence of the bodies we have suspected, and to separate them, in order to examine them individually, acetic acid must be added in excess, which will dissolve the phosphate of lime and the double phosphate, leaving the precipitated oxalate of lime, which is insoluble in this acid, free and intact.

For the microscopic characters of this last salt, and to make

such micro-chemical proofs at this period, as will verify its identity, see the following chapter, on the microscopic character of these bodies. It is almost unnecessary to say that, if all the precipitate is dissolved by the excess of acetic acid, oxalate of lime will be absent, and we have now reached the

3d. We must now proceed to the detection of carbonate of lime. It is not precipitated from the mother water by an excess of ammonia, as has been already remarked, while the phosphate, and the ammonio-magnesian phosphate are. We will now add an excess of ammonia to precipitate these two substances, then filter, leaving the filtrate to be examined at leisure. To the filtered liquor, which contains the chloride of lime, (should any be present) add a solution of oxalate of ammonia in small quantity; the lime unites with the oxalic acid, and is precipitated in the form of oxalate of lime; the ammonia combines with the hydrochloric acid, forming the hydrochlorate of ammonia, which remains in solution. We may examine the deposit subsequently, to verify the micro-chemical characters of oxalate of lime. Should no precipitate be formed upon the addition of the solution of oxalate of ammonia, it is an evidence that the solution of the calculus contains no chloride of lime derived from the original carbonate.

4th. The object of this is, to detect the phosphate of lime, which is precipitated by the same reagent as the double phosphate. It will be necessary, therefore, to separate it into its constituent principles, to wit: phosphoric acid and lime, in order that we may remove the double phosphate. We take the precipitate which was left on the filter in the third experiment, consisting of phosphate of lime and of double phosphate, and dissolve it in acetic acid; then, to decompose the phosphate of lime, and leave the ammonio-magnesian phosphate separate, we add some solution of oxalate of ammonia. The lime, which is in the phosphate, unites with oxalic acid of the oxalate of ammonia, forming oxalate of lime, which is precipitated; and the phosphoric acid remains in solution, where we will find it, after having filtered the solution to remove the precipitated oxalate of lime, which deposit we will verify by examination under the microscope, as in the preceding experiment.

5th. This experiment is for the purpose of separating the ammonio-magnesian phosphate from the remaining liquid. We

simply add a little ammonia to precipitate it, and then examine it, in the manner explained in the succeeding chapter, it must be collected on a filter, the same as has been done with the other precipitates, successively, in order that we may subsequently dry and weigh them, to determine approximately the quantity of each principle which is found in the calculus.

6th. There still remains the fluid from which we have precipitated the last compound body, and in which is left the phosphoric acid resulting from the decomposition of the phosphate of lime. To complete the proofs of the presence of lime in the form of phosphate, we must now find this acid. Add to the liquor a solution of some salt of magnesia, as, the chloride, and some ammonia; by a double decomposition, the double ammonio-magnesian phosphate will be formed and precipitated; it must be collected and examined, the same as the preceding, under the microscope.

7th. We now weigh the various products which have been gathered on the filters, after having dried them, in order to estimate their relative proportions in the calculus.

Portion C. This is submitted to the action of boiling water to extract uric acid and its compounds, if the calculus contains any, and the presence of which may be suspected by the indications given during the examination of portion A, otherwise it would be useless to undertake this experiment. All the urates, as well as uric acid, are soluble in boiling water without being decomposed, and each will be deposited separately in its proper crystalline forms, although united together in the same solution, as soon as the water becomes cold.

We must reduce this portion to the finest powder possible, by trituration in an agate mortar; then place it in a sufficiently large platinum capsule, (or test-tube of glass,) with two or three hundred times its weight of distilled water, boil for fifteen or twenty minutes, and filter while hot. On cooling, the crystals fall to the bottom, which, being scarcely soluble in cold water, may be separated by decantation or filtration, and examined and analysed with the greatest exactitude, by means of micro-chemistry. It is here, in fact, when experimenting on the organic constituents of calculi, that the great advantages of this means are more clearly shown.

Heretofore, before the microscope had been employed to any great extent in the analysis of calculi, it was believed that these

substances were not sufficiently soluble in water, to enable us to arrive at any exact results by micro-chemistry; and this part of the analysis, so very important, presented great difficulties, which are completely overcome by the micro-chemical means which I have instituted. The following are, in part, the difficulties to which I allude; they are the same as those which are met with in the analysis of natural mineral waters, as well as of urine:—

The impossibility at first—having reduced the compound bodies to their constituent elements, to wit; the urates into uric acid and their bases—the impossibility, I say, of making a precise estimate of the relative proportions which exist among these substances, or of the proportion of combination between the mediate principle and the different bases which are found dissolved in the acid, by which these substances are decomposed into their constituent principles.

The urates are all decomposed by hydrochloric and concentrated acetic acid, etc., and uric acid always loses its original character by the action of nitric acid; once decomposed, their original recomposition becomes impossible. Water does not change their chemical nature; it dissolves without decomposing them, and as I have remarked, deposits them, without the action of any reagent in crystalline forms peculiar to them, and which may be collected, examined and isolated, and their physical and chemical properties be readily determined by the aid of micro-chemistry.

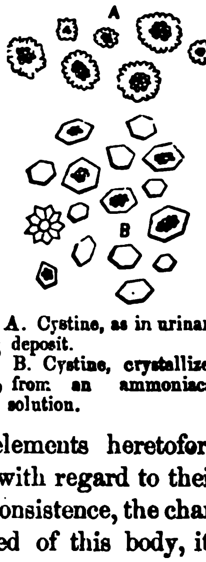
After long and especial examinations of uric acid and urates, when artificially prepared, as well as when met with in urinary deposits, including vesical calculi, I feel no hesitation in saying that, the method which I have advised for their analysis, to wit, by pure water, is, under all the circumstances, the best, the easiest and the most strictly exact. There is much less chance for error in the determination of the true character of the urates contained in calculi submitted to analysis, by this than by any other means; beside, it allows us to make a second analysis of each substance separately, and enables us to determine with greater accuracy, the relative proportions of the different urates which may be found in the same calculus. In a word, it is the only exact method.

It will be very easy, to verify, by the chemical decomposition of a calculus composed of urates of different bases, how much uric acid is contained in its combinations, and what quantity of each base. This is not the question which interests the physician

and physiologist; it will not aid us to replace these together, nor to determine the proportions in which they existed previous to their decomposition into their constituent principles; beside, they may unite in various proportions, as will be shown in the following chapter, in which will be explained the second part of the analysis, the importance and interest of which is by no means diminished. We must except from the preceding processes of analysis, three kinds of very rare calculi to which I will briefly refer.

Cystic Oxide. Cystine, (*see fig.* 83.) an organic substance very seldom met with in calculi, requires a separate analytical process, It is volatilized by heat, exhales a garlicky odor on burning, which is very characteristic, is soluble in nitric, sulphuric, phosphoric, hydrochloric, or oxalic acids, the other vegetable acids do not dissolve it. The sulphate and the phosphate are in the form of a gummy mass, deliquescent, from which it may be precipitated by the carbonate of ammonia. It is very soluble in sulphuric ether, and forms into hexagonal crystals upon the evaporation of the ether; it is insoluble in water or alcohol. To sum up, calculi, composed of this substance, behave so differently from those composed of the elements heretofore referred to, that we can never be deceived with regard to their character. The crystalline aspect, the waxy consistence, the character and the yellow color of calculi composed of this body, its peculiar odor on burning, its solubility in ether, and the form of its crystals will enable us to recognize it.

Fig. 83.



A. Cystine, as in urinary deposit.
B. Cystine, crystallized from an ammoniacal solution.

Uric Oxide. Xanthic oxide, as described by M. Marcet, is soluble in water, and its solution reddens litmus paper; it is also soluble in liquor potassa, ammonia, and in the alkaline carbonates. It is decomposed by nitric acid, leaving a yellow residue when evaporated to dryness, resembling that left by uric acid, when treated in the same manner without the addition of ammonia. We see how much analogy exists between this substance and uric acid, as regards the deep cinnamon color with red lamellæ, and the action of chemical reagents. The chemical analysis of this kind of calculi has caused it to be regarded as uric acid in a lower state of oxidation. Only a single calculus composed of

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this body has been found; and having been analysed only once, there may have been some error. I doubt its existence as a body other than uric acid; in every instance, its analogies with this last are so well marked, and its behavior with chemical reagents so similar, that I am disposed to give them the same analytical formulæ. (Since Marcet's discovery of this body, it has been found once by Stromeyer, who furnished portions of it to Unger, Wohler and Liebig for analysis.)

Fibrinous Calculi. M. Marcet has also made an analysis of a calculus called *fibrinous*, on account of its properties. It has a yellowish brown color, similar to that of beeswax, and of nearly the same density. Its surface was unequal, but not rough to the touch; its texture was more fibrous than stratified, and its fibers were in rays from the center to the circumference; it was slightly elastic; exposed to the flame of an alcohol lamp, it burned, blackened, and emitted a peculiar animal odor, and left a carbonaceous residue. It was soluble in water, and in hydrochloric acid; nitric acid equally dissolved it, but the solution gave no red or yellow matter on evaporation; which proves that the calculus was not composed of xanthic oxide, nor of uric acid.

We have seen that the several substances precipitated together from a solution, preserve, each, its distinctive forms and characters, and which is true of precipitates, occasioned by chemical reagents, as well as of those effected by cold alone, without the aid of any direct chemical action. In the first class, are ranged inorganic and compound substances, those which are treated by hydrochloric acid, as oxalate of lime, phosphate of lime, ammoniomagnesian phosphate, etc. In the second class, are found the greater part of organic bodies, likewise with some compound; those which are soluble in boiling water, and which fall in crystals upon its cooling, as uric acid, urates, xanthic oxide, etc. Cystine does not belong to this class.

We have also seen that there is a possibility of separating and isolating, by means of chemical reagents, each body of the first class, so that we may examine and study them singly, under the microscope, in their forms, their dynamic and static properties, and their manner of action when submitted to the influence of chemical reagents; and which will enable us to determine their true character with certainty, presenting to us an apparent homogeneous precipitate in its proper crystalline form. The study of

their second class, that of organic substances, is very difficult. They are precipitated together, as with the others, but they materially differ from them, inasmuch as they can not be separated without becoming partly decomposed, and deranging the analysis. Here, then, the microscope aids to enlighten us; here, it acts its most important part. We select crystals of each kind from the precipitate, which we successively examine under the microscope, with the aid of chemistry. It is hardly necessary to state that all these substances, either naturally or artificially prepared, ought to be previously studied that we may act with correct ideas, relative to their nature and constituent formation.

We will now revert to the preceding chapter, following, step by step, the chemical changes there demonstrated, that we may examine and analyse each substance therein named, under the microscope.

Portion A. This is the portion which was submitted to the action of heat; it is useless to examine the remaining earthy bases under the microscope.

Oxalate of Lime. Portion B. We had here dissolved together by hydrochloric acid, and then precipitated by ammonia, the following substances: oxalate of lime, carbonate of lime, phosphate of lime, and ammonio-magnesian phosphate. These substances we have isolated by the chemical process explained, and then precipitated each one separately.

Fig. 84.

A. Octohedral crystals of oxalate of lime.
B. The same, when dry.
C. Dodecahedral crystals of oxalate of lime.
D. Dumb-bells—oxalurate of lime.
E. Oval forms of oxalurate of lime.

Oxalate of Lime, (*See fig.* 84) precipitated by a great excess of ammonia, immediately forms a white, homogeneous precipitate, which is soon found at the bottom of the vessel. It is precipitated much more slowly, if ammonia is added only in a small quantity, to slightly neutralize the solution; it presents four different crystalline forms:

1st and 2nd. Precipitated by a great excess of ammonia, it

presents, under the microscope, a mass of very black crystalline points, with small prisms about .008 of a millimetre in breadth, cut *en biseau*, which frequently unite in the form of a horse shoe, and in $\bowtie$. This black powder is very characteristic, and exists with no other body.

3rd. Precipitated slowly, being careful not to add too much ammonia, the distinctive crystalline form of the oxalate of lime is obtained; these are regular octaedres, formed by eight equilateral triangles; they are frequently from .006 to .008 of a millimetre.

4th. This form, which has received the name of ***dumb-bell crystals***, because of the two heads separated by a body, same as the gymnastic irons, has been described by Dr. John Bacon, Jr., of Boston, in the Edinburgh Review, Sept. 1848; I have never met with them, though I have found urate of lime precipitated from urine, which had the exact form of these crystals. (Dr. Golding Bird considers these dumb-bell crystals *oxalurate of lime;* but some authors doubt this.)

All the above forms resist the action of acetic acid; but, when concentrated hydrochloric acid is added, they are dissolved and disappear from the field of the microscope. With a little trouble, we may make all the crystalline forms reappear in the field successively, an experiment which will verify, in a positive manner, the identity of oxalate of lime. We take some of the precipitate on a platinum spatula and calcine it in the flame of an alcohol lamp; carbonate of lime will remain on the spatula. Place this residue on a glass slide of the microscope, and add to it, when in focus under the microscope, acetic acid, and oxalate of ammonia. We will see the residue disappear in the solution, on the addition of the acid, disengaging bubbles of carbonic acid gas; and after adding the solution of oxalate of ammonia, we will observe the characteristic crystals of oxalate of lime, reappearing in the field of the microscope.

Carbonate of Lime. Carbonate of lime has not a regular crystalline form. Beside, it is readily known by the development of carbonic acid gas, under the action of acids; its solution in water, gives an alkaline reaction, restoring red litmus paper to its original blue. When precipitated, it falls less rapidly than oxalate of lime, and presents a more flocculent cloud.

Phosphate of Lime. This has no crystalline form; it consists

of a powder essentially differing from that of the oxalate of lime, in its color, the absence of horse-shoe prisms, etc., which the oxalate presents when rapidly precipitated from a solution in which it is not combined with the phosphate. Its color is lighter, rather yellowish than black, and these indications are always constant and the same. To exclude any other substance, for by the doctrine of exclusion we determine the nature of the materials in question, we let a drop of oxalate of ammonia penetrate between the thin glass, covering the precipitate, and the glass slide holding it. We will then observe the collection of phosphate of lime to change into crystals of oxalate of lime, and, by the further addition of a salt of magnesia with the ammonia which has united with the phosphoric acid, left in the solution by the decomposition of the phosphate, crystals of double phosphate will form in the field of the microscope, readily recognized by their forms as indicated in the above cut. It clouds sometimes before precipitating. (*See fig.* 85.)

Fig. 85.

Mixed phosphates; amorphous phosphate of lime. A few drops of solution of sesquicarbonate of ammonia (ʒj of the salt to fʒj of distilled water,) added to urine passed after the digestion of a meal, will precipitate the neutral triple phosphate.

Ammonio-magnesian phosphate. This double salt, like the phosphate of lime, is dissolved by acetic acid, from which it is precipitated by the addition of ammonia. Its precipitate is white and flocculent, clouding the mother water for a long time. It presents several different crystalline forms, according to the manner of precipitation, whether suddenly, by the immediate addition of a great excess of ammonia, whether slowly, by the gradual addition of only sufficient ammonia, or whether they fall of themselves in crystals, by the cooling of boiling water, in which they have been dissolved. (*See fig.* 86.)

Fig. 86.

A. Prismatic crystals of triple phosphate.
B. Penniform crystals of triple phosphate.
C. Stellar and foliaceous crystals of triple phosphate.

The first form is constant and always the same. The cryst are in arborescent leaves, as seen in the cut, and which are

no other form of crystals; they are thin, semi-transparent, an never present regular surfaces nor angles.

The second form is ordinarily to be recognized by simple sigh The crystals appear to be formed by the combination of the prin cipal octædre with its first prism horizontal, and the prisn vertical.

Those crystals which precipitate very slowly from the water are larger, and present forms, surfaces, and angles, much mor varied and complex. They consist partly of the crystals of th second form, and partly of the combinations of several simpl forms of the regular system, to-wit: the combination of tw tetrahedals, or that of the regular octahedral and the hexahedra together, a combination which, in certain forms, has received th name of *cubo-octahedral*. The last two classes are more trans parent, although much thicker than the first. It is always easy t verify their character under the microscope; the first by its crys talline form, which is unlike any other substance, and the others by dissolving them in acetic acid, and precipitating them fron the solution by ammonia, when they invariably fall in crystals of the first form, having their characteristic foliage.

This method may be objected to, as not being sufficiently exact I will, therefore, add another, combining chemistry with the micro scope. Place two or three crystals on a watch glass; then ad to them a small piece of caustic potassa, and cover the glass wit red litmus paper, slightly moistened with distilled water. Th crystals become decomposed, the ammonia is set free, and change the red color of the litmus paper to blue, indicating thus the pres ence of ammonia; place a few more crystals on a platinum cap sule, and calcine them in the flame of an alcohol lamp—the resi due, consisting of carbonate of magnesia and phosphoric acid, w place upon a glass slide of the microscope, and then dissolve i by the addition of a drop of hydrochloric acid. Place this unde the microscope, and when in focus, add a little ammonia to it; a recomposition is wrought, resulting in a new formation of th double phosphate, which assumes the crystalline form already indicated.

Uric Acid. Uric acid, presents a greater series of differen crystalline forms than any other substance found in vesical calculi these forms are more frequently derived from the rhombic prism and are readily recognized, after a little experience. When mucl

of this substance is dissolved in boiling water, it is deposited, on cooling, almost invariably in small white crystalline spangles, which sparkle in the light, when viewed through the glass holding the solution. These spangles are almost always of the same form, either lozenge or rhombic prisms, to which are frequently added regular facets. They vary from 0.15mm to 2.00mm or 3.00mm in length; are transparent, and polarise light very well.

Fig. 87.

Fig. 87 represents varieties of Uric acid crystals, met with in different specimens of urine; they are of varying shades of color from the deepest orange to the lightest yellow, and may all be referred to some modification of the rhombus, square, or rectangle. A, serrated crystals, from very acid urine. B, crystals met with in long continued deposits, and calculous disease. C, crystals often found mixed with urate of ammonia, or oxalate of lime.

When there is not a considerable excess of uric acid dissolved in the water, the crystals fall much more slowly, assume a larger size, and of more decided form. When, however, the crystals of uric acid, or urate, are not promptly deposited from their solution in the mother-water, we have only to place a drop of the liquid on a glass slide, and allow it to dry, when the crystalline figures will appear, because it is impossible for the water to contain one of these substances, however small may be the amount, without depositing it on evaporation. These crystals often preserve a very

brilliant deep yellow color, or a well marked light straw color; sometimes, but rarely a sparkling deep red. They consist of lozenges in very distinct facets, of rhombic prisms, which are likewise provided with facets, and often with prisms of six faces, composed of the primitive dodecahedral with the first prism of six facets.

To analyse these crystals, we take some of them, and burn them on a platinum spatula; if no residuum is left, we place some others on it, add a drop of nitric acid, and gradually evaporate it, taking care to add one or two drops of ammonia, before it is entirely evaporated. The beautiful scarlet color, which indicates the formation and the presence of murexide, will soon appear.

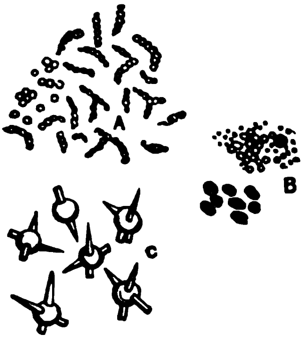
To continue, we place some of the crystals on a glass slide, adjust this to the focus of the microscope, and add acetic, or hydrochloric acid; the crystals are not changed by these reagents; they remain under the eye. Had urate of ammonia been acted upon as above, it would have disappeared by the heat, though the red color would have been equally manifested by the action of nitric acid and ammonia.

To the crystals which are yet under the microscope, and which have resisted the action of the above acids, we now add a solution of soda, potassa, or ammonia. The crystals of uric acid are dissolved; they disappear in an instant, and we see forming in the field of the microscope, either a mass of fine needles, amorphous collections, or round masses, black at the edges and yellow in the center; forms, characteristic of the urates, according to their bases, whether soda, potassa, or ammonia. To avoid the least possible error, we will add a drop of acetic acid, when the new forms will immediately disappear, and the original crystals of uric acid take their place in the field of the microscope.

Urate of Ammonia. Urate of ammonia (*see fig.* 88) dissolves in boiling water more readily, and in greater proportion, than any other organic body entering into the formation of vesical calculi. The precipitate of this salt formed by the cooling of the water, presents a physical character which at once distinguishes it from any other urate, or from uric acid. This character consists in its flaky aspect, which is more marked than any other substance with which I am acquainted. The flakes cause a cloud for a long time, before they fall to the bottom of the vessel; generally, they pre-

sent a pure white color; sometimes, however, they have a light straw color, but are never red or yellow. Examined by the microscope, this precipitate presents two forms, distinct from each other; we may meet with these together, or separately. The first form is an amorphous mass, almost always of a light straw color, approaching slightly to yellow; it occurs by rapid precipitation, from water highly charged with this urate.

Fig. 88.



A. Ordinary appearance of urate of ammonia.
B. Urate of ammonia, less common than the preceding.
C. Rare forms of urate of ammonia; the spicula being, probably, uric acid; occasionally observed in albuminous urine, and occurring in dropsy after scarlatina.

The second presents the form representative of the crystals of urate of ammonia. It consists of acicular needles, united together in large numbers to form crystalline globes. These needles are almost always met with isolated in the field of the microscope, in greater or less number; they are opaque.

To examine these different forms of urate of ammonia, micro-chemically, a small quantity should be placed in a platinum capsule, or in a watch glass, and a little caustic potassa be added to them. Cover the glass with a piece of red litmus paper, moistened with distilled water; the urate is decomposed by the potassa, and the presence of the ammonia is known by its restoring the blue color to the red litmus paper.

We next place some of the deposit on a platinum spatula; by applying heat, the whole is dissipated. We now heat another quantity with nitric acid and ammonia; the color indicative of the murexide soon appears. These two processes have verified the presence of uric acid, and ammonia, in the deposit, and the heat has proven that no earthy bases are combined with them.

We now place some of the crystals, or the amorphous mass, under the microscope; upon adding a drop of acetic acid, they instantly disappear, and we will observe plates of uric acid depositing in the place of the other, of the identity of which we may be assured, by pursuing the means named for the detection of uric acid; if we now add ammonia, the crystals of uric acid will disappear, and the crystals or amorphous masses of the urate of ammonia will at once present themselves.

Urate of lime. This substance may be ranged among the urates as the third, according to its frequency in the composition of vesical calculi; however, it never forms the principal part of a stone, and is met with rarely and in very small quantity. It is soluble in boiling water, but less readily than any of the other urates; it precipitates and falls very quickly to the bottom of the vessel in a sandy powder, which partly attaches itself to the sides of the vessel in the form of homogeneous layers. It is found under two distinct forms:

1st. Under an amorphous form, which it presents when precipitated from water holding a large quantity of it.

2d. In crystals, which are its type and which are formed by its slow precipitation; these are in the form of prisms, cut *en biseau*, semi-transparent, united so as to form globular masses from which the ends of the prisms pass out, or else in the form of a fan, or again in the form of two fans attached to each other by their two small extremities.

To make an analysis of these crystals place some on a platinum spatula and calcine it; there will remain a powder, gritty to the touch and soluble in hydrochloric acid. It is carbonate of lime, which disengages carbonic acid gas as it is dissolved. To prove that the residue is lime, it will be necessary simply to have recourse to the means indicated for lime, in a preceding paragraph.

Finally, submit the crystals of urate of lime to the action of acetic acid they disappear from the field of the microscope, and in their place we see the true crystals of uric acid. By the action of nitric acid and ammonia, the scarlet color appears, indicating the presence of murexide, which verifies uric acid under whatever form it may exist.

Urate of soda. This substance, (*see fig.* 89) is met with very seldom in vesical calculi, even in trace, and still more rarely is it found forming any considerable portion of a stone; like the other urates, it is soluble in boiling water, less readily than uric acid, but more so than the urate of lime or urate of magnesia. Its precipitate is not so flocculent as that of urate of ammonia, but falls rather quickly in the form of a somewhat gritty powder. Instead of two forms, this urate presents three distinct ones, the same as the urate of ammonia:

1st. Presents under the microscope a colorless amorphous powder.

Urate of potassa. The remarks on the urate of soda, as to its crystalline form and its general constituent formation, will likewise apply to the urate of potassa. Its behavior under the chemical reagent, chloride of platinum, which is proper for it as well as the urate of soda, is very different; so that the chloride of platinum serves as an unique reagent to clearly distinguish between these two bases, soda and potassa. We have seen that soda forms under the action of this reagent regular prisms, cut *en biseau*, which polarize light; potassa forms with this test regular octaedral crystals, which do not polarize light. These two salts, urate of soda and urate of potassa, may be present together in a stone, but in very small traces.

As stated in the preceding paragraph, chloride of platinum is the most powerful test for demonstrating the existence of these two bases, whether separated or together, giving to soda the prisms peculiar to it, and to potassa the regular octaedral form. When these two bases are found together they are verified to us by this reagent which gives to each its appropriate crystalline form; the potassa octaedral, being but slightly soluble in water, and not polarizing light; the soda prisms being very soluble in water and polarizing light. In addition we may employ the means indicated for the chemical investigation of these two bodies.

Urate of magnesia. Urate of magnesia is present in vesical calculi under two different forms; the first is the ordinary urate, whose existence has long been known; the second, discovered by myself, and which I have named the *bi-urate hydrate of magnesia*, differs essentially from the first in relation to the chemical equivalents of its base and uric acid; it also differs in a very marked manner by holding a large quantity of water of crystallization, which is not contained in the first. This is a very rare form; I have met with it but twice among several hundred analyses. These salts are as follows:

1. *Urate of Magnesia.* Next to the urate of ammonia the urate of magnesia enters the more frequently into the formation of vesical calculi; like the first it sometimes, but very rarely, forms the principal substance of a stone, but is frequently found in considerable quantity. This first form of urate of magnesia is more readily soluble in boiling water than the urate of lime, and less readily than the other urates. As the water cools, it precipitates in the form of a white powder, less flocculent than that of urate

of ammonia, and less gritty than the urate of lime; it is also precipitated quickly to the bottom of the vessel. Under the microscope this urate presents two distinct forms, the first consisting in amorphous masses, and the second, which is the crystalline type of urate of magnesia, is in the form of prisms, cut *en biseau* and more frequently united in great numbers to form globes. These prisms are also met with, in the field of the microscope, isolated; they are flat, like ribbons, semi-transparent, and possess the faculty of polarizing light; they are hardly .010mm in width, and of variable length. It sometimes happens that the large globes formed by the union of these prisms swim upon the surface of the water where they are developed; then it is not rare to find them of a white pearly luster, and of a silky texture, appearing to the naked eye like small pieces of white satin; they sometimes attain 1mm in width.

To analyse these crystals, we at first calcine them on a platinum spatula, when a white residue, carbonate of magnesia, will be left. Place this residue on a glass slide and dissolve it by the addition of a drop of hydrochloric acid; then add to the solution a drop of phosphate of soda, in solution, and of ammonia, when we will see the arborescent crystals of the double phosphate instantly appear in the field of the microscope, being formed by the double decomposition which has occurred among the substances entering into the solution. So much for the base.

To verify the presence of uric acid combined with the magnesia to form this urate, we proceed in the same manner as with the other urates and uric acid. For instance, we place some of the crystals on a platinum spatula, add some nitric acid to them, and then carefully evaporate in an ammoniacal atmosphere. It may be remarked here, that the examinations of the amorphous precipitates of all the urates are to be made in the same manner as those of their distinctive crystals.

I will add here that in case several urates are found united together, or with uric acid, which occurs frequently, it will be necessary to pursue the several processes heretofore named, in order to detect the bases, as ammonia, potassa, soda, lime, etc. Then, by the forms of the crystals and the general aspect of the precipitate, under the microscope, we will be able by a little practice to make a sufficiently exact quantitative estimate of the several substances.

2. *Bi-urate hydrate of Magnesia.* As yet I have only found a single and unique crystalline form for this novel urate. Its crystals present very remarkable differences from the other form of urate of magnesia, both in their form and in their behavior under chemical reagents. These crystals are quadrilateral with regular angles. They are generally near a millimetre, at least, in breadth, and from 0.30m to 0.50m square. At first they are transparent, of a clear straw color, like that of Canada Balsam, and may be mistaken for crystals of hippuric acid; they may be distinguished, however, from these, which are very soluble in water, while the crystals of this form of urate are insoluble in that fluid.

Exposed to the air for some time, these crystals become opaque and acquire a white silvery color, which phenomenon occurs in consequence of the loss of their water of crystallization, which these crystals hold from the moment of their formation. Submitted to the action of heat these crystals break with a noise, and are violently scattered around, so that great care must be taken to commence with a low heat and gradually drive off their water of crystallization. After calcination the residue preserves the form of the original crystals, is white, and presents the same chemical reactions as the residue obtained by calcining the crystals of the first kind of urate of magnesia. Submitted to the action of acetic acid, or ordinary hydrochloric acid, agents which promptly decompose the first form of urate of magnesia, these crystals remain intact. If concentrated hydrochloric acid is added we will observe after a few seconds, in the field of the microscope, that the crystals lose their transparency and assume a yellow color, which soon becomes a very deep black, if the action of the acid is continued. After three or four minutes crystals or small plates of uric acid commence being deposited; the crystal of urate of magnesia slowly loses its form and breaks into fragments resembling, to the touch, pieces of stone or gravel. These fragments are not dissolved; they remain in the field of the microscope, black and of irregular forms. At the commencement of the action of the acid upon these crystals there may occur a more or less considerable disengagement of bubbles of gas. I have not been able to obtain enough of these crystals to make an exact quantitative analysis of their constituent elements; this task

remains to be finished—I am only able to indicate the existence of this body.

[*Hippuric Acid.*—Hippuric or Uro-Benzoic acid (*see fig.* 90.) is generally the result of the decomposition of benzoic acid taken internally; it exists as a normal constituent in the urine of the horse and cow. It may be obtained from fresh urine containing it by evaporating the urine to a syrupy consistence, then adding about half the bulk of hydrochloric acid, and in a few hours a deposit will ensue; boil this in alcohol, filter and evaporate. Hippuric acid occurs in long, slender, four-sided prisms, terminating in two flat surfaces at the ends, or in the form of very small spangles. It is sparingly soluble in cold water; soluble in boiling water, alcohol, and sparingly in ether; dissolves without change in hydrochloric acid; is converted into benzoic acid by nitric acid: has a slightly bitter taste; and is fused by a strong heat, forming a reddish colored oil, having an odor like that of Tonka beans.

Fig. 90.

A. Ordinary forms of hippuric acid when benzoic acid is administered.
B. Different forms of hippuric acid in healthy urine.
C. Crystals of hippuric acid, by evaporation of an alcoholic solution.
D. Crystals do., from an aqueous solution.
E. Crystals do., after the action of hydrochloric acid on urine holding hippuric acid in abnormal proportion.

Albumen.—Albumen in urine coagulates by heat, and is not dissolved by nitric acid. Nitric or hydrochloric acids added to urine precipitate albumen. In an examination both heat and nitric acid should be used. In alkaline urine albumen will not be deposited until the urine is rendered slightly acid.

Mucus and Pus.—These resemble each other, but may be distinguished by *mucus*, not diffusing through urine by agitation; by its forming irregular, tenacious, ropy masses; by its solubility in liquor potassa, and by not being coagulated by heat or nitric acid. *Pus* diffuses through urine when shaken, forms a ropy, gelatinous mass with liquor potassa, and coagulates by heat or nitric acid, owing to the albumen which it always contains. *Oil*

globules are transparent and clear, and soluble in ether. *Blood corpuscles* are smaller than pus globules, yellow, and frequently appear in masses resembling rolls of coin.

Diabetic Sugar.—Urine holding sugar is pale, having a greenish tint, and clear, unless other principles are present, as phosphates or urates. It is usually passed in large quantity, and contains a diminished amount of urea. It may be detected by several methods. See Glossary, *Chemical Tests.*]

CHAPTER XIV.

PRACTICAL UTILITY OF THE MICROSCOPE.

In the preceding chapters frequent reference has been made to the practical utility of the microscope; but, in order to more positively determine this matter, it may be advisable to briefly enter into an exposition of what has already been accomplished by the instrument, and for considerable of which I am indebted to a work by J. Ferguson, of Edinburgh, entitled, "The Microscope, its Revelations and Applications in Science and Art." Of all the instruments which have been brought into the field of scientific investigation, "there is not one which has been more largely or more rapidly productive of most valuable results than the microscope. There is scarcely a region of the world, or an element of nature—scarcely an art or science—scarcely an atom of unorganized matter—scarcely a thallogen or acrogen—scarcely a seaweed or fern of the Silurian or Red Sandstone systems, onward to the loftiest dicotyledon of our own forests and gardens—scarcely an organ or tissue of animal, from the humblest crustacean or mollusc up to man 'monarch of all,'—upon which the microscope has not fixed its clear far-searching eye, and by which it has not triumphantly proved its powers." It reveals to us the (otherwise) "invisible things of God" in His minutest operations, and proclaims that *there* was the hiding of His power.—*Ferguson.*

This instrument has developed the startling fact that extensive tracts of land are composed principally of infusoria, as ascertained by the remains of their perfect and beautiful shields or siliceous coverings. On these lands, in many instances, large cities have been built, as for instance Richmond and Petersburgh, Va., together with other places in this country. In Europe they have been found in masses in Norway, Sweden, Hanover, etc.; and the city of Berlin, with its hundreds of thousands of human beings passing through its streets, has beneath it another living world of millions

and billions of creatures, invisible to the naked eye, and whose subterranean operations are said to have endangered the permanency of many of the buildings in that city. The microscope has not only made man aware of these facts, but it has also taught him that the clay beds of London, the wide-stretching chalk cliffs and downs of England, the sea bottom of the Mediterranean and the Baltic, the coral reefs in various parts of the world, the Turkey stone composing the pavement of the quadrangle of the London Royal Exchange, and the limestone of which the great Pyramid of Egypt is built, are all formed, principally, of the fossil remains of a once living mass of infusoria. The peculiar earth eaten by the natives of many sections of the globe, during a scarcity of food, as in Sweden, Norway, China, etc., and known by the names of *bergh-mehl* or *mountain meal*, *fossil flour*, etc., has been found to consist of animal or vegetable infusorial matter.

In the waters of the sea a class of microscopic vegetables have been discovered, termed Diatomaceæ, which are silently, invisibly, and constantly renewing the foundations of every sea, and increasing the soil of every land. They are of varied appearance and habits, are covered with an indestructible coat of silex which they withdraw from the waters in which they are found, bear a strong resemblance to animals, and are found in both fresh and salt waters in every part of the globe. They undoubtedly serve to purify the waters of their excess of carbonic acid, and to furnish food for many aquatic animals.

Fresh water not only contains Diatomaceæ, but another class of vegetation termed Desmidiæ, from their division into symmetrical halves, and Volvocineæ, from their rolling movements upon their own axis. Under the microscope, the forms of these several vegetables are most beautiful, and some of them quite magnificent. They vary in size, being from the $\frac{1}{1200}$th of an inch in diameter to the $\frac{1}{200}$th, and even larger. And it is from an investigation of the life and habits of these minute structures that philosophers have been enabled to arrive at "causes and effects," in what we may here term the grosser departments of science, and which, until the revelations of the microscope, were regarded as mysterious and incomprehensible. "If the whale, the largest animal, is one hundred feet in length, and the smallest monad is $\frac{1}{12000}$th of an inch, then the *common house fly* may be considered as occupying the middle place in creation."

But not only do waters contain minute vegetable life, but also animalcule, or microscopic animal life. These animalcules are of various sizes, shapes, and colors, some of them entirely unlike any thing that the imagination could previously conceive. Their structure varies from that of the most simple to that of a very complex one, and though a drop of some waters is said to contain 500 millions of them, yet they move rapidly about, without jostling or interfering with each other, creeping, walking, running, jumping, flying, or swimming according to the peculiarities of each family. In fact, they appear to be ever moving, and never sleeping. With some of them, four or five days is a very old age, while others may continue an existence varying from one to ten or twelve months. Nearly all of them are furnished on the exterior part of their bodies with numerous cilia, while a still higher organized family is furnished with an apparatus which when in motion presents the extraordinary appearance of a revolving wheel, in consequence of which these creatures have been termed Rotifers or wheel animalcules. Some live in tube-like houses made by themselves; some are found as parasites on other animals; and their methods of securing food, modes of reproduction, etc., are truly surprising. But it may be enquired of what use to man is all this vegetable and animal organization? The vegetables evolve oxygen which is breathed by the animalcules to sustain their existence, while the carbonic acid arising from the decomposed matters of the animals, answers as a nourishment to the plants, and thus by sustaining the vitality of each other, they render the water pure by consuming, between them, all putrifying organic substances, thus lessening the chances of disease and death to man.

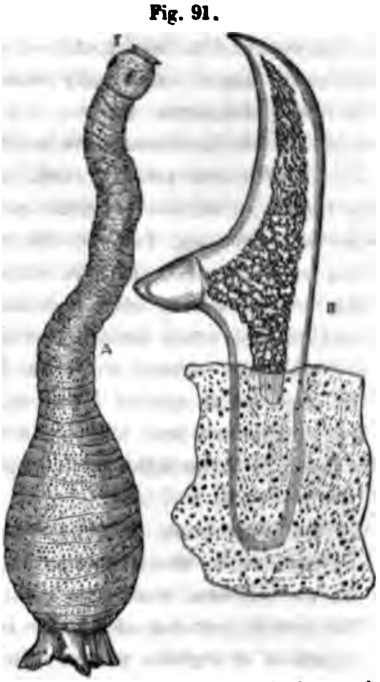
At various periods, history has given us accounts of showers of blood, of green snow, red snow, red-colored snow, black rain, red hail, etc., which have been witnessed in different parts of the globe, and which have occasioned much terror and alarm among the inhabitants of the places where these things occurred; the microscope has disclosed that these phenomena are due to the fall of variously colored microscopic vegetation and animalcules. Humboldt says, that "many of these agglomerations of siliceous-shelled microscopic organisms may perhaps float for years in the highest strata of atmosphere."

The origin of life has long been a mystery to physiologists; and

led to the ken of man, as certainly as the laws of gravitaunerringly direct the heavenly bodies in their orbits.

this age of adulteration and imposition when the very bread it is subjected to combinations with impure and unhealthy es by the dishonest manufacturer, the microscope comes to id, and reveals to us facts which the utmost refinement of ical processes have been unable to reach. The adulterations , coffee, sugar, milk, flour, , as well as of many of our valuable medicines, opium, urb, jalap, quinia, morphia, etc., have all been fully ex-, and a thorough acquaintwith these matters by the e at large, would tend to ct them from such gross eleterious impositions, and al manufacturers and to be honest and furnish ne articles of food and ine.—articles on which not health, but even life de-.

Fig. 91.



A. The animal in Measly Pork magnified. 1. The Teeth or Hooklets, 24 in number and arranged in a circle. B. One of the teeth greatly magnified.

eased conditions of vege-, meats, etc., which would highly injurious to health ife, are readily detected. the strange animal repre-l in Fig. 91 is found in is called measly pork; yet ut the aid of the microscope ct might never have been known. It is known to be the cause measles in pork, and is suppposed to be transformed in to that parasite so fatally known as producing the "stag-" and when in man, to exist in the form of tape worm—each se being the same animal under different modifications.

microscope has shown us that not only does the hair of one s of animal differ from that of another, but that even in the animal, the characters of the hair differ in different parts body. It has also acquainted us with the fact that the

blood-globules of animals are very dissimilar, in form, color, and size. The *smallest* blood-globule is that of the Java musk-deer, its average size being $\frac{1}{12325}$th of an inch in diameter; the *largest* is that of the Proteus, an animal of the Batrachian family, its size being $\frac{1}{337}$th of an inch. The average dimension of the blood-globule of a sheep is $\frac{1}{7000}$th,—of a dog $\frac{1}{3542}$d,—of a mouse $\frac{1}{3814}$th,—and of a man $\frac{1}{3200}$th of an inch. In some, the blood is globular, in others, oval or elliptical, etc.; and from the characters of the hairs, and of the blood, microscopists have not only been able to determine from what animals they were derived, but have been able to afford great aid in the investigation of cases of murder, as the following instances will illustrate:—

"One summer's eve, in 1837, a savage murder was committed on the edge of one of the forests in Normandy, France. A laborer, returning from his daily toils, was stricken down by the hand of an assassin, and from the nature of the wound inflicted, it was concluded that the deadly blow had been dealt with a hatchet. Another individual had been seen on the same eve, and about the hour of the commission of the dark deed, near to the scene of the murder. Suspicion fell upon him, he was arrested, imprisoned, and in due course, tried. As witness appeared after witness, their evidence brought the foul deed more and more closely home to the accused, and when it was at length proved, that, upon this man's cottage being searched on the very night after the murder, a hatchet with some stains of blood, and with some hairs upon it, had been found in an out-house—the murmur went round the court that the evidence was complete—the counsel regarded the conviction as certain—the judge seemed ready to pronounce his doom; and the unhappy accused felt that he was lost. But in God's good providence one man was there, who had clearly watched the progress of the trial, and who by no means concurred in the otherwise unanimous opinion of the guilt of the pannel. It was M. Orfila, the distinguished toxicologist. He asked leave from the judge to examine the hatchet; and to such a man as Orfila, his request was not refused. On submitting the blood and the hairs to the scrutiny of the microscope, Orfila ascertained that the hairs were the hairs of a deer, and the blood that of the same animal, which the accused *had said* he had found wounded, and had killed with his hatchet, as he returned from his daily toils! Orfila communicated the result of his *microscopic trial*—a

thrilling sensation ran through the audience—the counsel were confounded—the judge felt himself constrained, at the eleventh hour, to find that the charge was not proved, and the accused was released from the bar, and as from under the sharp axe of the guillotine. The worth of the testimony of the microscope, and the justice of the decision of the court, were soon proved to the satisfaction of all, for the real murderer was thereafter discovered, acknowledged his guilt, and was executed."

"A few years ago, a girl, nine years of age, was found lying dead, her throat cut, in a plantation in Norfolk, (England.) Suspicion fell upon the poor murdered girl's mother, who had been seen by several persons to lead her child to that plantation on the day on which the murder was committed. But the accused coolly and confidently maintained her innocence, admitted that she had been with the murdered girl near the spot where she had perished, but declared that the girl had wandered from her side in quest of flowers; and that after long in vain searching for her, she (the mother) had left her child in the wood where her dead body was afterward found. No evidence could at first be discovered to support the early suspicion that the mother was a murderess. A long and sharp knife was indeed found upon her, but, after a keen scrutiny, nothing particular was observed about it, except that there were on the handle a few hairs, so very small as to be scarcely visible. "Here is hair on the handle of your knife!" was the remark made to the suspected mother, in whose presence the examination was conducted. "Yes, very likely," was the immediate and composed reply; "and perhaps there is blood on it, too; for as I returned from the wood, I found a rabbit in a snare, and cut its throat with my knife." The knife was dispatched to London for microscopic investigation. It was there found that it had been washed. After very minute examination it was further found *that a fluid had penetrated between the horn handle and the steel lining. It was blood, but certainly not the blood of a rabbit*—rather, apparently the blood of a human being. After examining the hairs on the handle, the microscopist, who had been intentionally kept from all knowledge of the special facts of the case, unhesitatingly declared that they were *the hairs of a squirrel.* This was a crushing fact for the wretched mother; for a tippet [illegible] had been [illegible] neck on the day of the murder, [illegible] which

did the cruel deed must have passed; and that tippet was of *squirrel's hair.* On the trial the jury deemed this one fact, in connection with the circumstantial evidence, so conclusive, as to warrant them in finding the accused guilty; and, before the day of execution, the mother-murderess fully confessed her crime."

From the foregoing brief statements, may be learned some of the advantages which have already been derived from the introduction of the microscope into the arts and sciences, and from them the reader may readily imagine how extensive may its field be in the future, and how great its benefits to man. And the microscopists, those well versed in the subject of microscopic investigations, are always *well paid* for their services in those cases where legal or medico-legal questions, are to be determined, as well as in cases of adulterations, etc. "The study of the living world, of the hitherto unrecognized tenants of the earth, the ocean, and the air, must for centuries to come call forth all the resources of science, and summon to the microscope intellects of the highest order. Its objects are infinite in number and exciting in interest; and it will require ages to discover and to develop the countless organizations of being, and the strange functions of life, yet concealed from our view. The microscope, imperfect though it be, is the instrument by which these great results will be achieved; and when it has acquired new powers of penetration and enlargement, it cannot fail to reveal to us marvellous secrets, lifting the veil which shrouds the mysteries of our intellectual nature, and throwing light on questions which human reason has not ventured to approach."

I will close this subject by relating one more instance in which the practical utility of the microscope is manifested.

"In the summer of 1855, a large sum of gold belonging to the Russian government was forwarded, packed in a box, along one of the railway lines in Prussia. On the arrival of the box at its destination, it was found that the gold had been abstracted, and a quantity of sand substituted in its room. The national police detectives were immediately set to work, but all their efforts, backed by all the appliances of the wealth and power of the government failed to lead to any discovery. At first, it was supposed that the *sand* might show at *what station* the robbery had been effected; but there was sand at one station, and sand at another, and sand at all the stations along the railway line; and so the

trace seemed lost. But it was shrewdly suggested that the sand in the box should be submitted to the microscope; and when so examined, this sand was found to contain a peculiar minute organization. Specimens of sand were then brought from all the railway stations. On being examined, it was found that only the sand of one station contained the peculiar organism discovered in the sand of the box. At this station, then the robbery must have been committed. The clue thus given was followed up; and so the microscope brought to light that little organism in the box, so that little organism brought to light the parties who had placed the sand in that box, and committed the robbery.

From the following taken from the Cincinnati Times, Oct. 20th, 1858, it will be seen that by combining photography with the microscope, the astronomer may procure permanent and perfect microscopic charts of the heavens, which he may examine at his leisure, and without the aid of a telescope:

"*Celestial Photography.*—One of the most interesting and valuable of the many unexpected and extraordinary results of the discovery of Daguerre of the art of taking reflected impressions of objects by the effect of light, is its application to delicate astronomical observations. The art of the photographer is now made subservient to the science of the astronomer. A cluster of stars, a nebulous mass, or a planet, with its satellites, are now printed by their own light upon chemically prepared glass, so perfectly as to enable the astronomical observer to apply to the impressions thus obtained a microscopic lens of high power, and thus analyse and examine the objects under investigation more closely and minutely, and more at his leisure, than he could possibly do by the simple aid of the telescope. In fact the object as seen through the telescopic glasses, is imprinted upon a plate of collodionized glass, with the same distinctness and magnitude that it is upon the retina of the eye of the observer; and this printed image, thus fixed and retained, may then be still further magnified, and much more powerfully than was possible by the eye-glasses of the telescope. Of course a much more thorough and intimate knowledge of its parts and peculiarities is thus effectually secured.

"This new art of celestial photometry is now in full practical operation at the Cambridge Observatory of Harvard University, under the direction of Prof. Bond, by whom the process has been brought to its present state of perfection. It is yet in its

infancy, however, though it is said that its first attempts thus far are quite equal to the most perfect results of older methods; especially in the process of resolving double and triple stars, and determining relative magnitudes. Mr. Bond, in fact, has shown in a recent paper that by aid of these photographic impressions, his means for the micrometer measurements of the apparent distance between the members of groups of compound stars, 'exceed in facility and accuracy the most refined processes now in use.'

"Further experiments are now in progress, and still higher attainments and still more important advantages may be anticipated from more perfect methods and chemical agents of a more delicate and subtle nature than those now made use of. Thus is science daily progressing in its investigations and discoveries, and thus is one art made to contribute to the perfection and utility of another. Already has photography advanced to a high and important position amongst the utilized discoveries of the age; and yet we may safely predict that the art, as practised to-day, producing continually, as it is, such beautiful and startling results, in connection with the microscope, the telescope, and the stereoscope, is not further advanced beyond the simple image produced by the camera of Daguerre, than its achievements in the future will exceed those of its present imperfect state; achievements with which the world is as yet by no means familiar."

PART II.

GLOSSARY

OF TERMS MET WITH IN

MICROSCOPICAL OBSERVATIONS.

s, MEANS SINGULAR; *p*, PLURAL.

A.

Abbreviate; disproportionally short in the part.

Abdomen; the belly; the lower part of the body.

Abnormal; unhealthy; irregular; contrary to the regular order of growth.

Abortive; not reaching perfection.

Acalephs; jelly-fish, etc., which possess the power of inflaming and irritating the skin when touched.—*Brande.*

Acarida; the tribe of mites and ticks.

Accessory; ramuli, differing from the ordinary branchlets, and for a special purpose; as in sea-weed, etc. Joined to another thing so as to increase it; additional.

Achyla prolifera, a parasitic little plant growing upon the bodies of dead flies lying in the water, to the gill's of fish, and occasionally on the bodies of frogs.

Achnanthes longipes, a diatomaceous plant, consisting of a series or chain of frustules, the first one having attached to one end of its lower margin a nearly straight stipe or footstalk.

Achromatic, lenses which exert a refractive power without producing either spherical, or chromatic aberration.

Achromatic condenser, an arrangement of one or more lens, to

bring the rays reflected from the mirror to a focus on the object; used principally with the higher powers. The achromatic condenser fig. 32, is used with the $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{12}$ and $\frac{1}{16}$ inch objectives. To use it, place the object to be viewed upon the stage of the microscope, and by means of a half inch or inch objective bring the object into correct focus; maintaining the focus of the objective, set the object aside, and place the condenser on the instrument; then, with the plane mirror throw the light up the tube of the condenser. This effected; next turn the mill-head screw on the side of the apparatus, in such a manner that an image of some adjacent object may be seen more or less distinctly crossing the field of the microscope, as a chimney-pot, window bar, etc.; when this is completed, turn the plane mirror toward a white cloud or other illuminating source, so as to throw a strong light through the condensing tube. Now, replace the object on the microscope stage, substitute an objective of a high power for the low one, bring the object into focus, and it will be seen highly illuminated. Condensers of various other forms are in use, according to the fancy of the manufacturers and the microscopists. For most purposes, the object-glass next below the one used, when placed under the object and properly illuminated by the mirror, forms an excellent achromatic condenser.

Acineta, from *acinus* a grape stone; minute granular concretions. A genus of infusoria which adhere together in bunches like grapes.

Acrocarpi, mosses in which the fruit is terminal.

Acrogens, plants which continue to grow upwards, increasing in altitude but not in diameter, as Ferns.

Actinia, a genus of Acalephs having the tentacula in rays or circles surrounding the mouth resembling the petals of a flower, including the sea-anemone.—*Cyc.*

Actiniform, in the form of rays like those of the sun.

Actinocyclus undulatus, a beautiful diatom, with six, eight, or ten radial bands or divisions,—discoidal frustules—and found in the infusorial earths of Bermuda, Richmond, Va., Oran, and in guano.

Actinophrys sol, the sun animalcule, a creature consisting of sarcode with tentacular filaments.

Aculeated, pointed like a prickle; furnished with prickles.

Aculeus, the sting of insects.

Acuminated, with a long tapering point.

Adiaphanous, not in the least transparent.

Adnate, adhering or growing to an object by the whole surface.

Agglutinated, united by some sticky substance as glue.

Aggregate, collected or grouped together.

Alæ, (*s. ala*,) wings of insects, etc.

Albuminous, consisting of albumen, as the white of egg. *Albumen* is reddened by Millon's test; rendered purple by Pettenkofer's; and is insoluble in acetic acid.

Alburnum, sap-wood.

Alcyonium, a genus of marine zoophytes, belonging to the order Anthozoa and family Alcyonidæ. Their polypes, when expanded, somewhat resemble a flower.

Alga, pl. *Algæ*, Subaqueous cryptogamous plants, as Sea-weeds or Fucus, Lavers or Ulva, and marine and fresh water Confervoids or chlorospores. Their structure is cellular or filamentous, without any entering vessels.

Alulæ, winglets.

Alveolate, having pits or hollow cavities, like honeycomb.

Ambulacra, (*s. ambulacrum*,) the narrow longitudinal portions of the shell of the *echinus* or sea-urchin, which are perforated by small orifices traversed by tentacular suckers, and alternated with the broad tuberculated portions.

Amœba princeps, a microscopic creature found in fresh and stagnant waters, etc., consisting of a minute mass of sarcode, without any evidence of a distinct organization, and constantly but slowly changing its form, putting forth one or more finger-like prolongations. They are found to contain within them other infusoria, diatoms, desmidiæ, algæ, etc.

Amorphous, without regular shape, not crystalline.

Amphigastres, *Amphigastria*, stipule-like bodies in some Hepaticæ.

Amphitropous, ovules of plants, which have the foraminal and chalazal extremities transverse with the hilum.

Amyloid, a substance found in the albumen of certain seeds, resembling starch, being, like starch, ultimately dissolved, and removed to furnish material for development. It sometimes is rendered blue by the action of iodine.

Anal, belonging to the anus, or vent.

Analogous, similar; counterpart; something like.

Anastomose, when the mouths of two or more vessels unite, or communicate with each other.

Anatidæ, a family of web-footed birds.

Anatifa, pl. *anatifæ*; a genus of cirrhopods.

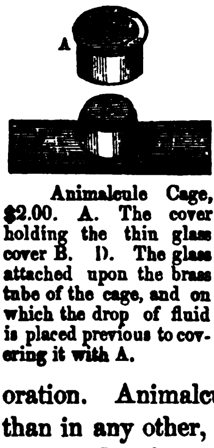
Anatropous, *Anatropal*, inverted; ovules of plants, which have the chalaza up and directed away from the placenta while the hilum and micropyle are at the base, toward the placenta.

Anenterous, animalcules having no intestinal canal.

Angle of aperture, the angle made by the most diverging of the rays of the pencil of light, issuing from any point of an object which can enter a lens, and which improves the defining power of an objective as the angle is increased.

Animalcule cage, a brass box made for the purpose of examining animalcules; a flat plate of brass with a circular orifice in its center, has one end of a short piece of brass tube, whose diameter is suited to that of the orifice, soldered upon or within said orifice; the upper or free extremity of this tube has a disk of clear glass fitted to it, for the purpose of receiving the drop of fluid containing the animalcules. Another tube, moveable, is fitted to the stationary one, sliding over it, and carrying at one end a thin glass disk; this acts as a cover to flatten the drop of fluid as may be required, and to prevent its too ready evaporation. Animalcules are much better examined in this way than in any other, as they may be held still without destroying them. *See fig.* 80 and 92.

Fig. 92.



Animalcule Cage, $2.00. A. The cover holding the thin glass cover B. D. The glass attached upon the brass tube of the cage, and on which the drop of fluid is placed previous to covering it with A.

Annelids, red-blooded worms with long bodies having many rings or annular segments, but no vertebræ. *Annulata*, *Annelida*, pl. *Annelidæ*.

Annulated, marked with distinct rings.

Annulosa, or *Articulata*, a division of the animal kingdom, the species of which are characterized by the body being composed of moveable pieces, jointed or articulated to each other. They are divided into two classes,—1, whose limbs are furnished with true articulations, and frequently the body; 2, whose bodies are simply annulated, and the limbs are non-articulated,

or absent. The division of articulated animals contains the *Entozoa* or intestinal worms; the *Annelida* or annulose animals or worms; the *Crustacea;* the *Cirrhipedia* or barnacles; the *Rotifera* or wheel animalcules; the *Myriapoda;* the *Insecta*, or insects; and the *Arachnida* or spiders.

Annulus, pl. *annuli*, a ring or circle; an elastic ring of cells in certain cryptogamic plants, lying in mosses, between the rim of the capsule and operculum,—in ferns, it springs from the pedicel, and is continued over the top of the capsule; when the capsule is mature, this ring assists in splitting it across so that the confined spores may escape. In ferns, the annulus forms an elastic band around the spore-cases, so as to preserve the spores safely until they are matured.

Anomalous, unnatural; not regular; contrary to general rule.

Antеal, in front of anything; forward.

Antennæ, two moveable, articulated appendages belonging to insects, like horns, and which are their organs of sensation or touch; they are vulgarly called *feelers*, (*s. antenna.*) Antennæ are situated on the head near the eyes; the joint upon which it moves by a sort of ball and socket motion is called *torulus;* the joint attached to this is the *scapus* or basal joint; the second joint is the *pedicella;* and the remainder is the *clavola.*

Antepectus, the under surface of the first ring of the thorax in insects.

Anterior, going before, in front of.

Antheridia, minute cylindrical, or fusiform stalked sacs or cells of the higher cryptogams, which discharge from their apex, upon the application of water, a mucous fluid filled with oval particles, and then perish. They are the sperm cells (*s. antheridium*).

Antherozoid, the granular, pellucid, spiral or pollen-like, moving substance contained in the antheridia. The fertilizing bodies contained in antheridial cells, having cilia or filaments; when set free, they spread themselves over the germ cells and their endochrome, and seem to melt away upon their surfaces. *See* Spermatozoids.

Anthozoa, a class of Zoophytes, whose polypes when expanded, resemble "animal flowers." *See Alcyonium.*

Antlia, or suckers, the principal part of the mouth in some insects by which they pump or suck up the juices of plants, etc.

Aperture, a hole, any opening.

Apex, the top of any thing; *apices*, the tops.

Aphides, a genus of insects belonging to the order Hemiptera, with long antennæ, deflected beak, and four erect wings, or wingless; plant-lice. *Aphis*, plant-louse. *Aphidæ*, plant lice.—*Encyc.*

Apical, belonging to the apex or top, pointed.

Apiculate, (leaf); furnished with a minute, but conspicuous point; terminating in a small point.

Aploperistomous, mosses are so called when the mouth of the sporange is furnished with only a single row of teeth.

Apodious, having no feet, or fins.

Apophysis, or *struma*, a swelling; a body in mosses intermediate between the seta and capsule, resembling the latter in form, but more solid.

Apothecia, little shields; the female or germ portion of the generative apparatus of Lichens, ferns, etc. The repository of the sporules. The term is sometimes restricted to open-fruited Lichens, while the close-fruited have the term "perithecium" applied to them.

Appressed, approaching the stem or branch so as to be nearly in the same direction.

Apterous, without wings.

Aquarium, vessels for holding and preserving fresh and sea water animalcules, plants, etc.; an artificial pond for the same purpose. A fresh water aquarium, or vivarium is a vessel containing the peculiar kind of fresh water which the animal preserved alive delights in. A *Marine Aquarium*, or *Vivarium* is composed of sea-water, or of an artificial sea water made as follows: take of common table salt three and a half ounces, Epsom salts one fourth of an ounce, chloride of magnesium two hundred grains troy, chloride of potassium forty grains troy, water four quarts. Dissolve, filter through a sponge in a glass funnel, and before placing marine animalcules in it, cover the bottom of the glass containing it with well washed small shore pebbles, having fronds of sea-weed growing thereon, as, the *ulva latissima;* let it stand eight or ten days in the sun, and then introduce the animalcules. To preserve the animals,

the sea-plants must either thrive, or new ones must be substituted for the old, until they do grow and become developed. *Gosse.* Mr. Warington gives the following as the best formula for making artificial sea-water; take of Sulphate of Magnesia seven and a half ounces, Sulphate of Lime two and three quarter ounces, Chloride of Sodium forty three and a quarter ounces, Chloride of Magnesium six ounces, Chloride of Potassium one and a quarter ounces, Bromide of Magnesium twenty one grains, Carbonate of Lime twenty one grains, Water ten gallons. The specific gravity should be 1.025. Scavengers should be added to remove decaying animal matter as it forms, as Periwinkle, Trochus, etc.

Aquatic box, see animalcule cage.

Arachnida, articulate animals having legs, but no wings, nor antennæ, (*mandibles*), and not subject to metamorphosis; as spiders, scorpions, mites, etc.

Arachnoidiscus Japonicus, or *A. Ehrenbergii*, a beautiful discoidal diatom found in sea-weed from Japan, guano, etc., so named on account of the resemblance of its markings to a spider's web.

Arborescent, branched, similar to a tree.

Archegonia, or ***Pistillidia***, flasked shaped bodies or cases, being the ovules, or female organs in mosses and other cryptogamic plants. (*s. archegonium.*)

Arcuated, bow-shaped, arched, crescent-shaped.

Areolated, marked like a pavement, or with lines so as to give the appearance of net-work.

Articulated, having joints or hinges.

Asci, (*s. ascus*,) spore tubes or cases of apothecia, containing two, four, eight, or more spores, which at maturity are projected from the apothecia with some force.

Ascospores or ***Thecaspores***, spores consisting of free cells, with a double coat, developed free in the cavity of a parent-cell or sac.

Asteroida, Alcyonian zoophytes having only three or four pairs of broad, short tentacula, and resembling a star when open.

Atropous, ovules erect on the placenta, with the hilum and chalaza turned toward the latter, and the micropyle at the opposite free end.

Attenuated, gradually tapering toward the apex, or base; growing slender.

Auricle, the outer ear; a little ear.

Avertebrate, without vertebræ or backbone.

Avicularia, (*s. avicularium.*) birds head processes of some polyzoa, each one of which has two mandibles, one of which is fixed, the other moveable, very much like the jaws of a bird; while the polyzoary lives, the avicularia keep up a constant nodding and snapping action.

Axillary, in the angle called the axil, formed by the junction of stem and branch.

Axis, the central portion or main stem; central portion of the frond. That part of the embryo, which terminates in the direction of the micropyle, in the form of a little root.

B.

Bacillaria, a genus of diatoms, formerly called "stick animalcules." They are found in every kind of water; and consist of simple siliceous shells, of a prismatic shape, which often appear in a zig-zag condition, in consequence of incomplete self-division; each link of the stick is an individual diatom.

Bacilliform, shaped like a little wand or stick.

Basal, at or pertaining to the base.—*Say.*

Basidia, (s. basidum,) spore cells of fungi, from free points.

Basidio-spores, spores matured by out-growth from free points, (*basidia.*)

Beaks, the continuation of the body of *univalves* in which the canal is situated.

Bergh-mehl, mountain meal or flour; diatomaceous deposits in Norway and Sweden, yielding many beautiful fossil microscopic forms.

Bi-acerate, pointed at both extremities.

Bicuspid, divided into two points; bisected.

Biddulphia pulchella, a beautiful diatom.

Bifarious, parting in opposite directions; with leaves, arranged in two rows.

Bifid, two-cleft; bisected; halved.

Bilabiate, two lipped; having a pair of lips.

Bilobed, having two lobes.

Binocular microscope, a microscope with one objective, and two compound bodies and eye pieces, for using both eyes at a time; it is said to have a beautiful stereoscopic effect, giving solid forms to the objects examined. Messrs. Grunow of New Haven,

manufacture these microscopes, which cannot be used, however, with objectives higher than ½ in. or ¼ in.

Birotulate, resembling an axle and two wheels.

Biserial, in two rows or series.

Biseau, a French word applied to crystals—" taillee en biseau" meaning, cut square to the axis,—bevelled,—or, at right angles with the axis.

Bi-spinulate, knobs at both ends. *See Spinulate.*

Bizarre, whimsical, fantastical, strange, queer.

Black ground illumination, a method of oblique illumination by which transparent objects are presented luminously, sailing on a dark back-ground.

Blastema, a germ, formative substance, the general formative element of tissues; the granular gelatinous basis of the ovum; the axis of growth of an embryo; the thallus of lichens.

Blowpipe. The extreme end of the blue flame made by the blowpipe is the hottest part and is called the " reducing flame;" the outer faint rim of light is the " oxidizing or oxidating flame."

Bothrenchyma, pitted tissue; large pitted tubes occurring in most kinds of wood.

Brachionus pala, one of the Rotifera, loricated, and found in standing waters; there are several varieties.

Brachyourous, with a short tail, or abdomen.

Branchiæ, the respiratory organs of water animals which extract oxygen from the air contained in water. (*s. branchia.*)

Bronchial, relating to the bronchi or subdividing branches of the windpipe in the lungs.

Bryozoa, see Polyzoa.

Bulbels, a peculiar kind of gonidia.

Bulbules, little bulbs; in which gemmules or ova are found.

Bullated, blistered, having elevations like blisters.—***Martyn.***

Byssoid, forming tufts of slender filaments; silky or flax-like.

Byssus, fine thread-like filaments; a peculiar collection of silken filaments, extending from the extremity of the foot, by means of which certain bivalve shells are firmly attached to stones, rocks, etc.

C.

Caducous, decaying or dropping off hastily or soon after maturity.

Cœloma, (pl. *Cœlomata*,) a hollow or cavity; in medicine, a circular and superficial ulceration of the cornea.

Cæspitose, coming from, or connected with turf.

Cæsius, grey.

Calcareous, limy, consisting of lime mostly.

Callous, hardened, of a horny or cartilaginous substance.

Callus, any horny or bony excrescence.

Calyptra, a hood, veil, or thin transparent membrane which covers the pistillidia or fertile bodies of mosses, and remains attached to it until the capsule is more or less matured.

Cambium, a tissue-forming juice; a mucilaginous semi-fluid matter, composed of cells of very delicate structure, which gradually become converted into wood, tissue, ducts, spiral vessels, etc.; in phanerogamic plants this substance always separates the bark from the wood, and is that portion of the plant, wherein all new growth occurs.

Cambium tissue, occurring in the growing regions of all plants having stems, is composed of minute cells of variable form; closely packed and densely filled with protoplasm; it is a transitional structure, forming the first stage of all the rest.—*Mic. Dict.*

Camera lucida, a prism attached to a microscope, for the purpose of drawing the magnified image of objects, measuring them, etc. *See fig.* 35.

Campanulate, shaped like a bell.

Campylodiscus costatus, a diatom of saddle shaped curvature, with ribbed markings, found in fresh and salt water, and in infusorial earths; there are several varieties.

Campylitropous, ovules in which the form is altered by their points being turned down, the entire structure becoming bent or folded upon itself, without disturbance of the relative position of the hilum and chalaza, while the micropyle is brought down to the vicinity of the hilum.

Canaliculate, furnished with a little groove, canal, channel, or furrow.

Canaliculi, pores, little canals, grooves or fissures; (s. canaliculus.)

Cancellated, having transverse lines crossing longitudinal ones at right angles.

Capillary, fine and long; like hair.

Capillitium, the sporiferous structure of Fungous plants, consisting of a collection of simple or anastomising filaments, either

attached to the peridium, and forming a kind of net-work, from between the meshes of which (probably the seat of their development) the spores fall out; or free and discharged with the spores.—*Mic. Dict.*

Capitate, applied to antennæ when they terminate in a knob; to terminate in a head, knob, or button; developing in a head.

Capsule or *theca*, the spore or seed case of mosses and other cryptogams.

Carapace, the shell-like covering of animalcules. (*See Lorica.*)

Carinate, having a longitudinal prominence on the back like a keel; applied to a corol, calyx, or leaf. *Carina*, keel.—*Martyn.*

Carnivorous, subsisting on flesh.

Carnose, of a fleshy substance; of fleshy consistence.

Cartilage, a white elastic substance, smooth and much softer than bone.

Cartilaginous, stiff, gristly.

Catenulate, having little rings, joints or chains.

Caudal, belonging to the tail, termination or extremity.

Caudate, possessing a tail, or extremity.

Caulescent, possessing a stem.

Cell or *Utricle*, that peculiar formation upon which, either in an isolated or aggregated condition, the existence of animals and vegetables depends. The vegetable cell is an imperforate vesicle or membranous sac enclosing a liquid cell-sap; its wall is formed of two layers, the inner being exceedingly thin and delicate, albuminous, and the first formed,—the external being thick, strong; and made up of cellulose. The contents of the cell are usually more or less colored, and are called collectively "endochrome." The animal cell is similar to the vegetable but has no "cellulose wall." When cells give rise to other cells they are called the *parent* or *mother cells*, and the internal newly formed cells are termed *daughter cells.*

Cells of diatoms, the apparent holes in them.

Cell, a deep or shallow cavity formed on a glass slide by gold size, varnish, glass rings, etc., in which objects are mounted and preserved for microscopic examination.

Cellular, consisting of cells.—*Kirwan.*

Cellulate, having little cells.

Cellulation, the cellules, or number of cellules.

Cellules, minute, microscopic cells.

Cellulose, a substance almost identical with starch, and destitute of nitrogen; the external layer of the vegetable cell-wall is principally composed of it, and is sometimes called the "cellulose envelope." It is colored blue by sulphuric acid and iodine. (*See Protoplasm.*)

Cements, these are used for closing the cells in which microscopic objects are placed for preservation, also for fastening pieces of glass to each other, to form cells, etc.

1. *Asphalte Varnish* is made by dissolving Egyptian asphaltum in boiling linseed oil, or oil of turpentine, or in a mixture of the two. It is known by the name of "Brunswick Black," forms a very useful cement, both for making very thin cells, and also for fixing on the glass covers. It is brittle when dry, and is apt to crack and admit air, but this may be obviated by adding to it a little quantity of a solution of India-rubber in mineral naphtha. The best Brunswick Black is made by boiling together four ounces of asphaltum, and four and a quarter ounces of linseed oil, which has been previously boiled with half an ounce of litharge until quite stringy; the mass is then mixed with half a pint of oil of turpentine, or as much as may be required to make it of a proper consistence. It is often improved by being thickened with lamp black. This cement is soluble in oil of turpentine, and may be used when diluted alcohol is employed as the preservative fluid.

2. *Black Japan*, is made by melting fifty pounds of asphaltum, then adding eight pounds of dark animé, and ten pounds of dark amber, again melting, then adding fifteen gallons of boiled linseed or drying oil, and one pound of litharge. The whole is to be boiled until perfectly mixed and stringy, then cooled and thinned with oil of turpentine. It is a good cement to form thin cells, and becomes very hard and dry when exposed to gentle heat in an oven. Asphaltum is soluble in oils, oil of turpentine, petroleum, and ether; insoluble in acids, alkalies, water, and alcohol.

3. *Canada Balsam* should be kept in well closed vessels; when it becomes too thick it may be thinned by the addition of turpentine. It is used, either alone, or digested at a gentle heat with sufficient ether to render it slightly more fluid, for mounting objects.

A very useful cement for fine work is made by gently heat-

ing and evaporating Canada Balsam to dryness, and then dissolving the residual resin in ether. This cement dries as rapidly as collodion, is perfectly limpid, and does not coagulate. It will be found convenient to have two kinds of balsam, one fresh and in a very fluid state, the other much older and thicker. These should be kept in wide mouthed bottles, and well closed to prevent all dust from getting in.

4. *Compound Cement*, is made by forming a solution, of the consistence of thick syrup, with shell-lac dissolved in naphtha, and then mixing it, with an equal quantity of gold size. It should always be kept in well closed vessels, is always ready for use, and may be applied cold. It is not brittle, dries rapidly, and is not acted upon by the ordinary preservative fluids.

5. *Diamond Cement*, is made by dissolving mastich one ounce in sufficient alcohol to dissolve it. Also steep isinglass one ounce in water till it is softened, then dissolve it in pure brandy, enough to form a jelly, and add gradually a solution of gum ammoniac one fourth of an ounce rubbed down in a small quantity of water. Mix the two preparations together, and boil to the consistence of syrup. Keep it in a well corked vial. As it becomes solid on cooling, it must be liquefied before applying it, by placing the vial in some warm water. It is used as a cement, and as a mounting fluid for some objects, and forms an excellent cement for broken glass and china. Water dissolves it.

6. *Electrical Cement*, is made by melting together five parts of resin, one of beeswax, and one of red ochre. The addition of Canada balsam two parts renders it much more strongly adhesive to glass. It must be used when hot, and may be employed for fastening brass or wood to glass in electrical apparatus, for making thin flat cells, etc. Quekett recommends melting together two ounces of black resin, one ounce of beeswax, and one ounce of vermillion.

7. *French Cement*, is made by placing some common India-rubber in an earthen pipkin over a fire, stirring the whole frequently, until it has become a liquid mass. Then throw in small quantities of powdered lime at a time, stirring the mixture well until it becomes thoroughly incorporated; continuing the addition of lime until the mass becomes very thick

and tenacious. A fine rich brown color may now be given to it by the addition of a little Venetian red, or vermillion.

As this process occasions a very offensive smell, it should be performed out of doors; and care should be taken that the mixture does not take fire, which would spoil it. It may be kept in tin or earthen ware pots. This cement never becomes hard, so that large quantities of fluid may be kept in a cell, the cover of which is fixed on with this substance, without danger of the glass cracking in consequence of the alteration of the volume of the fluid by variations of temperature. When pressed upon wet glass, the thin layer of fluid is expelled by the pressure, and the cement adheres firmly.

In order to fix on the cover of a preparation jar with this cement, all that is necessary is to roll a small piece out between the hands, and lay it all round the top of the jar or cell; by pressing it gently with the finger and thumb, it adheres firmly to the glass,—the cell is then filled with the preservative fluid, and the cover applied. This cement will only answer where water, weak spirit, or creosote and naphtha in solution, are the preservative liquids.

8. *Gum Arabic Cement* is made by dissolving three parts of gum arabic, and one part of sugar in distilled vinegar. Used as a preservative, and to cover slides with paper; a little calomel added to this gives it greater consistence, when desirable. Another preparation may be made by dissolving two parts of gum arabic, two of white sugar, and one of gum tragacanth in a small quantity of water.

Gum water thickened with powdered starch, will be found a very useful cement for fixing the glass cover on preparations mounted dry; when dry it forms a hard white coating. The addition of a little arsenious acid will prevent the growth of mildew. Gum waters should always be strained before being placed in the bottle for use.

9. *Gutta Percha Cement*, is made by adding fifteen parts of oil of turpentine to one part of finely cut-up gutta-percha, and dissolving by the aid of a continued heat with stirring. The solution is then strained through a cloth, and one part of shell-lac is added, and dissolved by heat and stirring. The heat is to be continued, until a drop, when allowed to fall upon a cool surface becomes nearly hard. When required for use, the mixture

is to be heated and a small quantity placed upon the slide upon which the cell is to be fixed; the slide itself is then to be heated. This cement is used for attaching cells of gutta-percha or India rubber to glass slides. It may be rendered thinner by the addition of more oil of turpentine.

10. *Japanner's Gold Size*, or *Severe Dryer*, is prepared by boiling twenty-five parts of linseed oil for three hours with one part of red lead and one third of a part of umber; then pour off. Next, take white lead and yellow ochre, well pulverized and mixed in equal parts, and add successive portions of it to the oil, rubbing and mixing it up well, till a tolerably thick fluid is formed, and which must be once more thoroughly boiled. This should be about three years old before it is used; when too thin it may be thickened with a little lamp black, or litharge. Used for making thin cells, for fastening the covers of cells, for cementing cells to the glass slides, etc. It may be obtained at most paint shops. It is not acted upon by spirit, or water, but is dissolved by oil of turpentine.

11. *Marine Glue* is made by dissolving one pound of caoutchouc in four gallons of coal naphtha. One pint of this solution is mixed with two pounds of shell-lac. To use it, it must be heated, by laying thin slices on the slide and exposing it to the flame of an alcohol lamp, with much care. Any excess may be removed by scraping with a chisel, and then finishing with a solution of caustic potassa, being careful to dry the slide thoroughly. It is used more generally for cementing cells to glass slides.

Marine glue may be used alone, or it may be cut into very small pieces, and melted in some convenient vessel, together with nearly an equal amount of Canada balsam; as soon as the mixture commences boiling, remove from the fire, and apply to slides or cells, with a brush. It will be more efficient as a cement, if the glasses be slightly heated immediately before applying it, the whole being allowed to cool together. This cement hardens when cool, but may at any time be rendered sufficiently liquid to use, by the application of a proper degree of heat. (The addition of some mastich to the above glue, after the caoutchouc and lac has been dissolved, is said to increase its adhesive character, when applied to glass.)

Another mode of preparing it is to digest from two to four

parts of India-rubber, cut into small pieces, in thirty-four parts of coal tar naphtha, over a gentle fire, and keep stirring the mixture until the India-rubber is completely dissolved. Add to the solution, which has the consistence of thick cream, sixty-two or sixty-four parts of powdered shell-lac, and heat the mixture over a gentle fire, with incessant stirring, until the mass is thoroughly fused and intermixed; pour the mass while hot upon metal plates in thin layers, and let it cool. Marine glue is dissolved by naphtha, ether, or solution of caustic potassa.

12. *Sealing-wax Varnish* is prepared by forming a solution thick enough to use with an ordinary brush, of the best sealing-wax in strong alcohol. It is used only to give the last coat as a finish, and may be variously colored according to taste.

13. *Shell-lac Varnish* is prepared similarly to that of the sealing-wax, and is used in the same manner. Each of these varnishes should be kept well closed to prevent the spirit from evaporating.

A *Cement* for microscopic cells has been recommended, made as follows: Take of shell-lac, and plumbago, each, three parts, asphaltum one part, melt together, and add of Gutta Percha dissolved in chloroform twelve to twenty parts, as may be required.

14. *Transparent Cement* is made by dissolving seventy-five parts of India-rubber in sixty parts of chloroform, and then adding fifteen parts of mastich. This forms an excellent cement, remaining fluid at 60° F. and drying quickly when placed upon a slide; it may be used for similar purposes as the marine glue.

Mr. S. Lenher's preparation is fifteen grains of caoutchouc dissolved in two fluid ounces of chloroform, and when the solution is effected, add mastich, half an ounce; allow the whole to macerate for a week and filter under cover; it may be applied cold, with a brush. Where great elasticity is desirable, more caoutchouc may be added.

A good *India-rubber varnish* may be made by dissolving one pound of India-rubber, cut in pieces, in one fourth of a pint of rectified coal naphtha.

15. *White Hard Varnish*, is made by placing two and a half pounds of gum sandarac in one gallon of alcohol (60 p. ct.), in a strong, well closed vessel, and applying the heat of warm

water with occasional agitation until dissolved; next add one pint of pale turpentine varnish; mix well, and let the whole rest for twenty-four hours.

16. *White Lead* ground with drying linseed oil is sometimes used in making cells. It should be old and free from all rough particles. Sometimes oil of turpentine is added to it. It may be mixed up on a slab with a small quantity of gold size, or, if with a little litharge, it will dry more readily.

17. *Soluble Glass.* Melt together, by a very strong heat, Carbonate of Potash ten parts, Quartz or sand, free from alumina and iron fifteen parts, Carbon one part. The carbon promotes the decomposition of the carbonate of potash. The resulting mass, silicate of potash, is soluble in four or five parts of boiling water; the solution by evaporation yields a glass harder than common glass. As fast as one layer dries, another must be put on, and so continue until the layer or cell-wall is of the desired thickness. Carbonate of soda may be substituted for the carbonate of potash, the result then being a silicate of soda.

All these liquid cements or varnishes with the exception of the soluble glass, should be old, or kept some time before use; a black color may be imparted to most of them by mixing with lamp black. They should all be kept well covered, and when possible in wide mouthed capped bottles. Several other cements are used occasionally by microscopists, but the above are the principal ones. Pastes made of wheat, gum, etc., may be prevented from getting sour by the addition of a few drops of some essential oil.

Fig 93.

Cementing Pencil. See fig. 93. "When it is required to *Cement* the thin glass cover to the slide, the usual method consists in melting a portion of the cement in the ladle. It is then painted round the edge of the cover and the contiguous surface of the slide with a camel's hair brush, and smoothed off with a heated wire. The whole of these objects are effected by using the little instrument which I propose to call the cementing pencil. It is a brass tube, six inches long, with a conical bore, having a lid to screw on. When a small portion of the cement crumbled into

fragments, is shut into the tube, it is ready for use. In using this instrument, the extremity is gently heated in the flame of a spirit lamp, and when the cement begins to ooze out, holding the pencil like a pen, the point is traced along each side of the cover leaving a line of cement in the angle. It is thus laid on much easier than with a brush, and after a little manipulation it will be found that the point will suffice to polish off instead of using the flattened wire."—*J. Gorham.*

Centipedes, insects having a great number of feet.

Cephalopoda, a molluscous animal whose head is surrounded by fleshy arms or feet, which appear to issue from the head; by these arms they move themselves along, and seize their prey. Cuttle-fish, Nautilus, Argonaut, etc., are of this class of animals.

Cephalo-thorax, head united with the thorax, as with spiders.

Ceramidium, pl. *Ceramidia.* An urn shaped case, seen in Coralline sea-weeds, which has a pore on its top; from the bottom of the case arises a group of pear-shaped spores.

Cernuous, drooping, but less so than to be described as "pendulous."

Chalaza, that region of the interior of ovules, where the lower parts of their coats are confluent with the base of the nucleus.

Chelæ, pincers of insects.

Chelate, like a crab's claw.

Chelifers, jaws like crab's claws.

Chemical Tests, or *Reagents*, are frequently used in microscopical investigations, for the purpose of determining the chemical characters of the object under consideration, and among which those hereafter named are the most common. The apparatus necessary in a micro-chemical examination are chiefly,—test tubes of various sizes arranged on a stand; a few conical glasses of different sizes; one or two spirit lamps; small watch glasses; small porcelain basins; a small water bath; bottles to hold reagents; a small platinum capsule; a strip of platinum foil; a blowpipe; pipettes; glass stirring rods, etc., depending, however, on the kind of investigation.

1. *Acetic Acid* is useful on account of its rendering pus and the cell walls of animal cells transparent and the nuclei more distinct. It should be used strong, of sp. gr. 1.048; and likewise in a solution made by adding five parts of distilled water to the above. It renders epithelial structures transparent, and

is employed for testing phosphates, carbonates, etc. When added to mucus, the fluid part of the mucus coagulates, forming an opaque wrinkled membrane.

2. *Alcohol* will be required of various strengths, for the purpose of dissolving certain animal substances, and for separating them from other constituents, which are insoluble in this reagent. It also hardens animal tissues, and is used as a solvent for certain coloring matters, and for the removal of air from sections of wood and other preparations.

3. *Chloride of Calcium* one part to two parts of distilled water is used for determining the presence of cell-membranes. A cell with a soft and thin wall will become distended by adding distilled water to it, while chloride of calcium will cause it to collapse and wrinkle, which is not the case with a solid body, or when the outer covering is firm and resisting. A lump of camphor should be kept floating on the surface of the above solution when in its bottle.

4. *Chromic Acid* in a weak solution of a pale yellow-color hardens and preserves nervous and muscular tissues, so that thin sections of them may be made. It should be prepared as required.

5. *Corrosive Sublimate* in saturated solution renders very transparent bodies consisting of protein compounds more opaque and distinct, as the bodies and cilia of infusoria, etc.

6. *Ether* is chiefly used as a solvent for resins, fats, oils, etc., also for the removal of air. Highly refracting globules may by this agent be determined from oil-globules.

7. *Iodine* in solution, (iodine one grain, iodide of potassium three grains, distilled water one ounce,) is useful for dyeing and rendering very transparent objects more distinct, generally coloring them brown; and for coloring the cell membrane and the cell contents, starch, amyloid, the amylaceous bodies of the human brain, etc., blue.

A mixture of three drachms of pure acetic acid, with one fluidrachm of rectified alcohol, and six drops of diluted sulphuric acid, is a test fluid, under the microscope, for the merest atom of quinia. Place a drop of the suspected fluid on a glass slide and add to it a drop of the above [illegible] fluid; give time for a solution to take place, and then let [illegible] minute drop of the alcoholic solution of iodine be added, [illegible] circular [illegible]

or cinnamon colored spot, will be seen if quinia be present, followed by beautiful rosette-like polarizing crystals.

8. *Solution of Caustic Potassa* is a solvent for fatty matters, and acts best when heated. Most animal substances are dissolved by it; chitin remains unaltered; it separates many animal structures into their component cells, etc. When cold, it separates all protein bodies from fatty compounds, etc.; and also removes the foreign compounds with which the cellulose of the epidermal structure of plants is often imbued. It dissolves cystine which solution gives a black precipitate with acetate of lead; it forms a viscous, gelatinous mass with pus; it dissolves mucus and uric acid, the latter being precipitated from the solution by acetic, or muriatic acids.

9. *Sulphuric Acid* when *concentrated* is used principally in the examination of pollen and spores; it causes epidermic structures to swell up very much, and the cells to separate from each other so as to be readily isolated. In the examination of hair it renders the outlines of the cells very distinct. It dissolves uric acid, from which water precipitates it, and likewise dissolves cystine. When *diluted*, three parts of the acid to one of distilled water, it turns the external coat or cell-wall of plants, which have been previously moistened and dyed with the iodine solution, blue. This blue color may be uniform or in spots, and is frequently changed to a red after some hours. When lime is present it forms the acicular crystals of the sulphate.

Pettenkofer's Test, for bile or protein compounds. Place a very thin section or portion of the suspected tissue in a drop of simple syrup. This is then removed by means of a hair pencil, and a drop of diluted sulphuric acid added; in about ten minutes it renders the tissue violet red if a protein body be present.

10. *Millon's Test Liquid.* Dissolve metallic mercury in an equal weight of strong nitric acid, sp. gr. 1.4. The acid is first poured upon the metal; gas is copiously evolved, and as soon as the evolution ceases, a gentle heat is applied until the whole of the mercury is dissolved. After some hours the liquid portion is poured off from the crystals which have [illegible] subsided, and must be kept in a stoppered bottle. [illegible] albumen, casein, chondrine, crystalline, feathers, [illegible] fibrine, gelatine, gluten, horn, silk, wool, legumine [illegible] of a more or less deep rose-red color; but does not [illegible]

cellulose, cotton, gum-arabic, linen, and starch, when these are pure. The substance to be tested is immersed in the liquid, either in a tube or upon a glass slide with a cover, and heat applied by means of a spirit lamp, until boiling occurs, when the color appears as above remarked.

11. *Schultze's Test* for cellulose, which it colors blue; it does not destroy the tissues to which it is applied like the iodine and sulphuric acid. His directions for it are:—to dissolve zinc in hydrochloric acid; and the solution, in contact with metallic zinc, is to be evaporated to a syrupy consistence, and the solution must then be saturated with iodide of potassium. Iodine is then to be added, diluted with water if necessary.

Busk prepares it by dissolving one ounce of fused chloride of zinc in about half an ounce of water, and adding to the solution (which amounts to about an ounce fluid measure) three grains of iodine dissolved, with the aid of six grains of iodide of potassium, in the smallest possible quantity of water.

Radlkofer recommends zinc to be dissolved in muriatic acid, the solution to be evaporated at a temperature but little above that of boiling water, when a liquid of about 2.0 sp. gr. is obtained. This is diluted with water until its sp. gr. is 1.8; if its original sp. gr. was 2.0, twelve parts by weight of water must be added to 100 parts of the solution. In one hundred parts of this liquid, six parts by weight of iodide of potassium are to be dissolved at a gentle heat, and the mixture heated with excess of iodine until the latter is no longer dissolved, and violet fumes become perceptible over the liquid. This test should be kept in a well stoppered bottle. A drop of it may be added to a preparation placed in a little water.

12. *Nitric Acid* should be kept of two strengths; *diluted* with five parts of distilled water to one of acid, for separating muscular fiber cells; and, with two or three parts of water to harden some structures previous to cutting thin sections, and which may be afterwards rendered transparent by being treated [illegible] caustic soda. *Strong* nitric acid is used for sepa- [illegible] organic matter from the siliceous valves of the Dia- [illegible] them in it; also as a reagent; and to [illegible] from woody matter. For this latter [illegible] and nitric acid is preferable. [illegible] the object, a piece of wood

for instance, with an equal bulk of chlorate of potassa, into a long and moderately wide tube, and as much nitric acid as will at least cover the whole. The tube is then warmed over a spirit lamp; a copious evolution of gas takes place, upon which the tube is removed from the flame, and the action of the oxydizing agent allowed to continue for two or three minutes. The contents of the tube are then poured into a watch glass with water, from which the slightly cohering particles are collected and placed in a tube, and again boiled in alcohol as long as any color is communicated. They are again boiled in a little water. The cells may now be be isolated under the simple microscope by means of needles. The boiling with nitric acid and chlorate of potassa should never be carried on in the same room with the microscope, as its glasses would be injured by the vapors. Thin sections of vegetable tissue should be warmed for half or a whole minute in a watch glass; boiling is here unnecessary. The section is taken out, and treated with water in a watch-glass.

Nitric acid dissolves cystine, oxalate of lime, urea, and triple phosphates, converts hippuric into benzoic acid, and precipitates albumen.

13. *Muriatic, or Hydrochloric Acid* is employed for dissolving out the mineral constituents of certain tissues, such as bone or teeth. With heat it colors protein compounds blue. It precipitates albumen, uric acid from its salts, and dissolves the triple phosphates, oxalate of lime, and cystine. And is sometimes used for separating organic matter from the siliceous valves of diatoms by boiling.

14. *Solution of Caustic Soda* readily dissolves substances of an albuminous nature, as the epithelium covering mucous membranes in order to examine the arrangement of the structures beneath the basement membrane, also in investigating the termination of the nerves and vessels in papillæ and other structures. One part of caustic soda to eight or ten parts of water will be found a convenient strength. It dissolves cystine, uric acid, mucus, etc. For most purposes in microscopic research, this agent possesses advantages over potassa.

16. *Solution of Ammonia*, made by mixing one part of the strongest water of ammonia with three of water. It possesses the usual chemical tests, and dissolves most animal textures.

16. *Oil of Lemons*, or any other essential oil, for the investigation of pollen and spores, rendering them more transparent, removing any minute drops of oil which may be contained in the cavity of their cells.

17. *Solution of Nitrate of Baryta*, saturated, is employed as test for sulphuric and phosphoric acids. If the precipitate be sulphate of baryta, it will be insoluble both in acids and alkalies; if it be phosphate of baryta, it will be readily soluble in acids, but insoluble in ammonia.

18. *Solution of Nitrate of Silver*, two drachms of the crystallized nitrate to two fluid ounces of distilled water, is employed as a test for chlorides and phosphates. The *white* precipitate of chloride of silver is soluble in ammonia, but insoluble in nitric acid. The *yellow* precipitate of tribasic phosphate of silver is soluble in excess of ammonia, as well as in excess of nitric acid.

19. *Oxalate of Ammonia* in a filtered saturated solution is used as a test for salts of lime. Oxalate of lime is insoluble in alkalies and in acetic acid, but is soluble in the strong mineral acids. In testing an insoluble deposit for lime, it may be dissolved in nitric acid and excess of ammonia added; the flocculent precipitate is readily dissolved by excess of acetic acid, and to this solution the oxalate of ammonia may be added; the precipitate of oxalate of lime is favored by the application of heat. Many deposits of phosphates are not readily soluble in acetic acid, hence the necessity of first adding nitric acid, as above directed. Oxalate of ammonia mounted in Canada balsam forms a very beautiful object for the polariscope.

20. *Nitrate of Cobalt* in solution added to the ash obtained from urine, and then heated in the blowpipe flame, produces a blue head if alum be present in the urine.

21. *Chloride of Platinum* for detecting soda, and potassa in very minute quantities. The sodio-chloride of platinum crystallizes in prisms and plates which polarize light; the potassio-chloride of platinum yields several forms which do not polarize light. Place a small quantity of the suspected article on a piece of platinum foil, and direct the flame of an alcohol lamp upon it, continuing this until the article is consumed, or until an incombustible white substance is left. Place a small quantity of this substance on a glass slide, and add a drop of

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hydrochloric acid to it; then add a drop or two of a solution of phosphate of soda, and of aqua ammonia, and place a thin glass cover over the mixture. Upon immediately examining this under the microscope, if the residue first obtained by calcination be *magnesia*, arborescent crystals of the double phosphate of ammonia and magnesia, formed by the double decomposition which has occurred among the substances in the solution, will be seen.

If, however, the white residue be owing to some *salt of soda* in the suspected article, it will fuse at an elevated heat. Place a small quantity, as before, on a glass slide, and dissolve it in a drop or two of water, if it be carbonate of soda (or potassa) the solution will restore the blue color to reddened litmus paper. To the drop of this solution add a drop of a solution of chloride of platinum, and carefully evaporate over an alcohol lamp. Before the fluid is entirely evaporated, place it under the microscope, when, if the residue first obtained by calcination be *soda*, large, very transparent prisms of an indefinite length will be seen, which possess the faculty, in a high degree, of polarizing light; they are very soluble in water. But, if it be *potassa*, the crystals will not polarize light.

Chemical Tests for Urine. 1. *Chloride of Sodium in Urine.* Add a few drops of nitric acid to some urine in a test tube, and then add a few drops of a solution of nitrate of silver. If chloride of sodium be present a dense white precipitate of chloride of silver, which is insoluble in acids, will fall: but if chloride of sodium be absent, there will be no precipitate. Under the microscope chloride of sodium, when urea is present in the urine, crystallizes in the form of crosslets and daggers. It may be known from oxalate of lime, and cystine, by its solubility in water.

2. *Uric Acid*, is not dissolved by heat, is soluble in liquor potassa, from which it is precipitated by acetic acid, or hydrochlorate of ammonia. It forms compound or lozenge-like crystals, varying from colorless, to a dirty-white, yellow, pink, or red color.

3. *Urate of Ammonia*, amorphous, dissolved by heat but falling again on cooling, and by alkaline solutions.

4. *Phosphates* not dissolved by heat, nor alkaline solutions;

soluble in nitric, acetic, or hydrochloric acids. Crystallizes in prisms, simple pennæ, radiated or foliaceous.

5. *Oxalate of Lime*, is insoluble in water, acetic acid, and solution of potassa; soluble in nitric or hydrochloric acids without effervescence. It forms well defined Octohedral crystals. The *dumb-bells* are oxalurate of lime.

6. *Albumen* coagulates by heat, and also by nitric acid, causing a white precipitate. (*See King's Chemical and Microscopical Chart of Urinary Deposits.*)

7. *a. Sugar.* Mix together equal parts of solution of neutral chromate of potash, and liquor potassa, and label, "Test for Sugar." As this does not test cane sugar, use the following; (in grape sugar the green color is more or less intense with the above test, according to the proportion of sugar present). Add together equal parts of solution of bichromate of potash and liquor potassa. The color with this last is also green on boiling, but the saccharine fluid must be thick and syrupy.

To use these test-fluids, place some urine in a white evaporating dish, or a test tube, add a small quantity of the test and boil, when, if sugar be present, a sap-green color will be produced, from the decomposition of chromic acid; the reduced oxide of chromium is held in suspension by the potash. (*Jno. Horsley.*)

b. M. Luton's easily prepared and unchangeable "test for sugar." It acts at once without any previous preparation of the urine, and succeeds in cases where the ordinary tests act slowly and obscurely. Its action is not disturbed by the presence of albumen, urea, or uric acid.

To a cold saturated solution of bichromate of potash, add an excess of sulphuric acid in such a manner that some free sulphuric acid will be present when all the chromic-acid is liberated. The liquid will be of a beautiful, limpid, red color, and is composed of water, chromic acid, bisulphate of potash, and an excess of sulphuric acid.

To use it, add enough of it to the diabetic or suspected urine to impart a red color to it, then warm the mixture; a brisk effervescence ensues, and the color changes from red to emerald green, if sugar be present.

Chromic acid is an active oxidizing agent, particularly in the presence of another acid; it gives up some

to the sugar, and the result is carbonic acid, water, and sesquioxide of chrome, this last dissolves in the free sulphuric acid, and forms the persulphate of this sesquioxide.

c. Maumene's Test. Saturate a strip of white merino, (or white paper,) in a strong solution of chloride of tin, and dry it. A few drops of a very dilute saccharine fluid placed on the merino, or paper, and exposed to a temperature of from 260° to 300° F., immediately produces a dark brown, or black spot. (*See other tests in "King's Chart of Urinary Deposits."*)

8. *Quinia.* Mix together pure acetic acid three fluidrachms, rectified spirits of wine one fluidrachm, and dilute sulphuric acid six drops. To a drop of the suspected urine placed on a glass slide, add a drop of the above test-fluid,—give them time to combine,—and then add a very minute drop of an alcoholic solution of iodine. A yellow, or cinnamon-colored compound of iodine and quinia is formed, if quinia be present even to the $\frac{1}{100,000}$th of a grain, and finally the beautiful rosettes or crystals of sulphate of iodo-quinia are formed; no heat is required.

Under the microscope, with the selenite plate or stage, and a Nicol's prism beneath, these crystals assume the two complementary colors of the selenite plate,—red and green if the pink-stage be employed,—blue and yellow if the blue selenite be used. (*Herapath.*)

9. *Iodide of Potassium.* First, add starch to the urine, then a few drops of nitric acid, or solution of chlorine; if iodide of potassium be present the blue iodide of starch will be precipitated.

10. The presence of *sulphur* in the smallest particle of horn, hair, nails, etc., may be detected by placing the article on a piece of platinum, and, by means of the blowpipe, heating it with the addition of a small amount of carbonate of soda—a drop of the nitro-prussiate of soda being then added to the melted mass, will, if sulphur be present, cause it to assume a magnificent purple color. In the heating, carbonaceous matter may also require to be added, according as a deoxidizing action is or is not required. *Prof. J. W. Bailey.*

Chitin or *Chitine*, the horny substance which gives firmness to the tegumentary system and other parts of several insects, etc. When the above structures are exhausted successively with alcohol, ether, water, acetic acid and alkalies, the chitin is left

retaining the original form of the texture. It is dissolved by the concentrated mineral acids without the production of color, and is not dissolved by solution of potassa. It contains nitrogen. (*Mic. Dict.*)

Chlorophyll, the green coloring matter of plants; it is a substance of a waxy nature. Tincture of iodine turns chlorophyll yellow-brown; sulphuric acid gives it a more or less deep blue color. Chlorophyll is soluble in ether and alcohol, which discharge its green tint. Preparations containing chlorophyll lose their green color when put up in chloride of calcium. Water has no action on chlorophyll.

Cholesterine, a substance existing in most animal fluids, and which crystallizes in thin pearly rhombic plates. It is insoluble in water, or solution of potassa; soluble in ether, or boiling alcohol, crystallizing on cooling. It is most easily procured from a gall-stone by boiling it in alcohol, and allowing the solution to cool. (*Mic. Dict.*)

Chromatic Aberration, an unequal refrangibility of the different colored rays of light, by which, not being all converged to the same focus, the edges of an image exhibit more or less broad fringes of color.

Chromatophores, the innumerable pigment cells of Cephalopods; these cells enclose variously colored substances, so that according to the degree of their contractions or extensions, the animal may vary the hue of its skin, the same as the chameleon.

Chrysalis the name given to the second stage of the young of most insects, into which they change from the state of larva or caterpillar, during which they remain motionless and without receiving any nourishment; as with moths, locusts, dragon-flies, butterflies, etc.

Cilia, vibrating, hair-like or microscopic filaments in plants and animalcules. They are best seen when their movements are retarded, or entirely arrested by means of a solution of opium, iodine, corrosive sublimate, etc., or, by adding a solution of carmine, or of indigo, to the fluid containing them. Hairs seated upon a bulb.

Ciliated, furnished with cilia, microscopic or like the eyelashes.

Cimex, bugs.

Cingulum, a girdle; the subpersistent connecting membrane of certain diatoms, which holds the frustules after self-division in

a geminate union, until the self-dividing process is renewed. *W. Smith.* A transverse series of bony pieces connected by flexible joints are termed "cingula."

Cinereous, ash-colored.

Cirrhi, curls or tendrils; styles or hooks. Animals of the Cirrhiped kind.

Cirrhipeds, animals belonging to the Barnacle-shell family, with long articulated, and slender feet curved together into a curl, and which are constantly being protruded and withdrawn again through an aperture in the shell.

Cirrhopoda, see Cirrhipeds.

Cirrhose, *Cirrous*, terminating in a curl or tendril. (*Martyn.*)

Clavate, shaped like a club, or growing thicker from the base.

Closterium Lunula, a microscopic plant belonging to the tribe of Protophytes, called Desmidiaceæ; it is oblong, crescent-shaped, with a beautiful green-colored internal arrangement. There are several varieties of Closterium.

Clypeus, a shield; upper anterior portion of the heads of insects; a term applied to the large protothorax in beetles; *clypeiform*, like a shield.

Coarse Adjustment, an external tube in which the compound body slides, or a coarse rack and pinion attached to the compound body of microscopes, for the purpose of quickly moving the object glass to or from the object on the stage, and is also adapted for effecting a focal adjustment of the low powers.

Coccidium, among the Algæ a kind of conceptaculum; it is either external or half immersed in the substance of the plant, and usually imperforate. There are two kinds, one contains beneath a membranous pericarp, a tuft of filaments whose cells are finally changed into spores; the other contains, beneath a thick pericarp, a mass of spores or a central placenta. (pl. *coccidia.*)

Coddington Lens, a lens made of a sphere of glass, having a deep groove ground in its equatorial part, and filled with opaque matter, so as to limit the central aperture; objects to be seen with it must be applied close to the objective segment of the lens.

Coleoptera, a name given to an order of insects having four wings, the first two of which are hard elytra, of a horny or crustaceous consistence, divided along the center of the back, longitudinally, and covering the pair of membranous wings lying

underneath them, as in the fire-flies, water-beetle, horned beetle, may-bug, etc.

Collenchyma, a form of cellular tissue where the walls are greatly thickened with softish secondary deposits; it occurs beneath the epidermis of many herbaceous plants, in the fronds of the larger Algæ, of Lichens, etc. (*Mic. Dict.*)

Columella, a small projecting thread, pillar, or pedicel, continued through the axis of the spore-capsule, or hollow urn-like case of mosses and some other Cryptogams, varying in form, and to which the spores are attached when young.

Compensation, the adjustment of the object-glasses for covered objects. When an object glass is corrected for uncovered objects, any covering of glass will create a different value of aberration to the first lens, which previously balanced the aberration resulting from the rest of the lenses; in order to overcome or compensate the aberration resulting from the various states in which an object may be thus placed, an adjustment is placed on the best objectives, by which the lenses composing them may, by means of a milled head, be separated or brought together, as required to perfect the compensation, according to the thickness of glass covering them, or density of fluid enveloping them, and which must be done by the microscopist during his examinations, at the same time using the fine adjustment to obtain a correct focus. All first class objectives are marked to designate the situation of the adjustment for examining *uncovered* objects. In object-glasses of large angle of aperture the definition of covered objects will be imperfect without a correct compensation. *See fig.* 39.

Compound Body, the brass tube belonging to a microscope, from an inch to an inch and a half in diameter, and eight or ten inches in length,—to the upper part of which the eye-pieces are adapted, and to the lower, the object-glasses. Its quick motion to or from the object is effected by a coarse adjustment, while the fine adjustment regulates the slow motion of the objectives which brings objects into a perfect focus with the higher powers.

Compound Microscope, a microscope in which not less than two lenses are employed; one, the object-glass, to form an enlarged image of the object, and the other, the eye-glass, to again magnify that image.

The red coral of commerce is the internal skeleton of the *Corallium rubrum*. *Mic. Dict.*

Cordate, heart-shaped at the base; (see Obcordate).

Coriaceous, of a leathery consistence.

Corneous, composed of horn; horn-like.

Corrugate, to ruffle, gather, furrow, or wrinkle.

Corymbose, level-topped; the branchlets of different length, but level or nearly so at the top.

Coscinodiscus, a genus of beautiful diatoms, of discoidal shape, the disc being covered with areolæ somewhat resembling a sieve.

Cosmarium, a beautiful desmidiæ, formed of two lobes united together by a narrow isthmus; there are several varieties.

Costate, rib-like; furnished with ribs. *Costæ*, ribs.

Cotyledon, a lobe of the seeds of plants, which envelopes and promotes the existence and growth of the embryo plant, and then decays.

Coxa, the hip of insects, composed of two joints.

Crenated, toothed, notched, jagged, scolloped.

Crescentic, like the moon in a state of increase; half moon-shaped.

Crustacea, animals fitted for aquatic respiration, having the body and legs covered with a crust-like shell, the limbs being articulated or jointed, as, lobsters, crabs, shrimps, etc.

Cryptogamous, plants not having flowers, in which the fructification or stamens and pistils are not distinctly seen, as, ferns, mosses, mushrooms, sea-weeds, etc.

Cuculliform, like a hood.

Cuneate, shaped like a wedge.

Cuspidate, leaf furnished with a somewhat lengthened and rigid point, terminating in a bristly point. *Martyn.*

Cyclops, a family of fresh-water and marine crustacea, with apparently but one eye on the middle of the head, as the Cyclops Quadricornis. There are, however, two eyes or ocelli clustered together so as to appear as a single one.

Cyclosis, that general motion of latex, or the vital fluids of plants, which passes through vessels of a peculiar kind, and which are diffused through the system of plants without interruption; in contradistinction to *rotation* or the movement of fluids in

separate cells,—although sometimes used synonymously with *rotation*, but erroneously.

Cylindrical, round or circular and elongated, the diameter being uniform throughout.

Cymbelloid, shaped somewhat like a boat.

Cymbiform, carinate, navicular, resembling a boat in shape.

Cypris, *Cyprides*, a species of fresh water Crustacea, enclosed in a bivalve shell, which swim by means of cilia. *Mantell.*

Cyst, a bag or covering, a bladder.

Cytoblast, see *nucleus*.

Cytoblastema, of Animals, or, for brevity, *Blastema*—The amorphous proteine substance in which the animal and vegetable cells are formed, or of which they are wholly composed. *Mic. Dict.*

D.

Daphnia Pulex, the arborescent water flea, a minute fresh water Crustacean.

Deciduous, a leaf falling off in the autumn; a deciduous calyx is one that falls off together with the coral and stamens. *Martyn.*

Deflexed, *Deflected;* bent downwards.

Deltoid, triangular; with three angles.

Demodex Folliculorum, a parasitic animal found in the sebaceous follicles of the human skin, especially in those of the nose; also called "steatozoon folliculorum." (*See fig.* 74.)

Dendritic, appearing branched like a tree.

Dentate, toothed, indented, jagged.

Denticulated, having diminutive teeth.

Dermestes Lardarius; the bacon beetle, which is black, about an inch and three lines long, and has a grey transverse band with black points on the base of the elytra. Its larva is about half an inch long, and the segments of the body are covered with long, scattered brown hairs which are used as test objects.

Desmidiaceæ, *Desmidiæ*, a class of minute fresh water plants of a bright green color, (*endochrome*), whose external coat is of a horny consistence, but not siliceous, calcareous, nor mineral. They are not easily preserved in any of the preservative liquids at present known.

Dextral, on the right.

Diaphanous, clear and transparent.

Compound Tunicata, molluscous animals enclosed in a leathery or cartilaginous tunic, and having no ciliated tentacula.

Compressed, flattened laterally.

Compressorium, (*see fig.* 31,) an instrument to flatten or expand semi-transparent objects when under microscopic examination. It also serves to keep animalcules at rest under the field of the microscope, without killing them; the animalcule cage will answer a similar purpose.

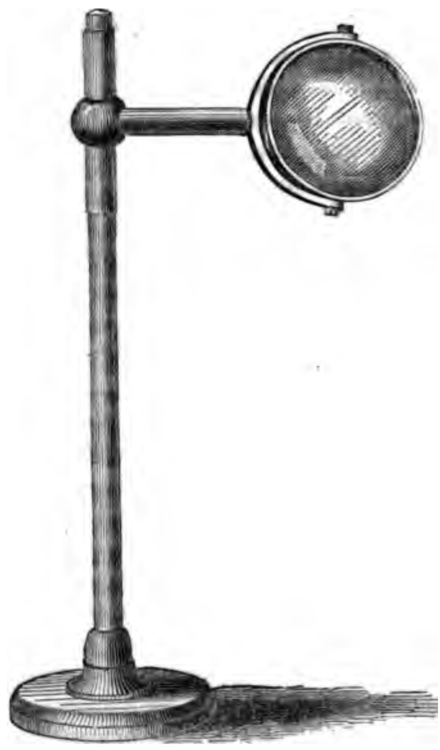
Concave, hollow excavated, indented, arched; concave lenses are those in which one or both surfaces are hollow.

Concentric, rings, orbits, circles, and spheres of various diameters, situated on one plane, and having a common center.

Conceptacle, a hollow case containing spores. They are variously called, ceramidia, coccidia. perithæcia, etc.

Conchifera, *Conchiphera*, inhabitants of bivalves; an animal that developes or is enveloped within a shell as the oyster, mussel tortoise, etc.

Fig. 94.



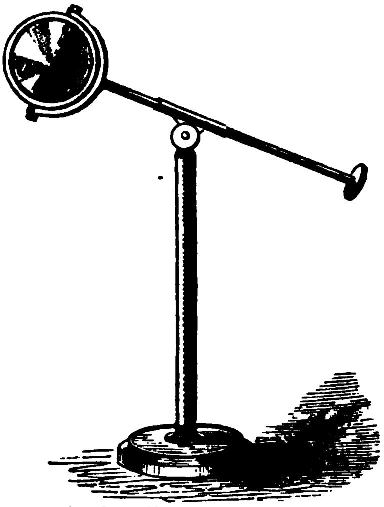
Large Bull's Eye Condenser.

Condenser, a lens, or series of lenses used for the purpose of converging the rays of light upon an object, and thus increasing its distinctness; there are several kinds of condensers.

Condensing lens, a lens to illuminate opaque objects; it is also called a bull's eye condenser." It is a plano-convex lens carried on an arm separate from, or attached to some part of the microscope, and is moveable in nearly all directions, so as to receive the rays of light from any source, and concentrate them

upon the object. The flat side must be toward the object, so as to converge the light upon it. The smaller bull's eye condenser may be used in the same way, when the lower powers are used. When both are used together, the large condenser is placed near the lamp or source of light, with its plane surface toward the light, and is arranged that the diverging rays given off from it may be so converged as to fill the entire circle of the small condenser, which, with its convex surface toward the object, is adjusted to continue these rays, and converge them to a focus upon the object. *See fig.* 94 and 95.

Fig. 95.



Small Bull's Eye Condenser.

Confervæ, the name of an extensive section of the *Algæ*, consisting of simple, tubular, jointed water weeds. *Pen. Cyc.* The lowest forms of Algæ.

Conidia, reproductive cellules growing directly from the mycelium. Secondary granules of Lichens that are neither stylospores nor spermatia.

Conjugation, the conjunction, reunion, or fusion together of any pair of animalcules or vegetable cells; it is connected with reproduction.

Connivent, leaves closely united. *Eaton.*

Conoid, resembling a cone.

Constricted, drawn together at intervals as if tied.

Continuous, without interruption, prolonged. *Norris.*

Contorted, twisted, or leaning on each other obliquely. *Martyn.*

Convex, a prominence, arched projection or swelling on the external surface, generally of a spheroidal or globular form; convex lenses are those in which one or both surfaces have a spherical protuberance.

Convolute, twisted spirally, coiled, rolled together.

Coral, a term applied in general to the calcareous polypidom or skeleton of Polypes or Zoophytes, especially that of Corallium.

Double Concave, a lens with both surfaces concave.
Double Convex, a lens with both surfaces convex.
Dredge, a drag net for taking zoophytes, mollusca, etc.
Duckweed see *Lemna*.
Duplicative Subdivision, a mode of division by which certain infusoria, protozoa, desmidiæ, diatoms, etc., are reproduced or multiplied; the body dividing into two halves, each of which assumes the form of the primary body, and after a time when matured, these again divide, and so go on continuously.
Duramen, heart-wood.

E.

Ecdysis, the moulting process which the Crustacea undergo.
Echinated, set with spines, or bristled like a hedgehog. *Martyn*.
Echinodermata, *Echinoderms* are radiate animals, whose envelop is more or less leathery or crustaceous, opaque and filled with reticulated, calcareous little bodies. Their structure is complex. Their external surfaces are covered with spines, prickles, long slender rods, club-shaped bodies, or tubercles.
Echinoderms, star-fish, sea-urchin, etc.
Ectozoa, ectozoons or parasitic animals inhabiting the exterior of animal bodies, as lice, fleas, etc.
Edentulous, toothless.
Elaters, elastic spiral threads or fibres in the sporangia of Hepaticæ; when the spore-case ruptures, these spiral filaments suddenly extend themselves and scatter the spores in every direction.
Elliptical, oval, but having the longitudinal diameter twice the length of the transverse.
Elytra, wing cases of insects; the hard coverings which conceal their wings (*s. elytrum*).
Emarginate, notched on the margin.
Embryo-sac, a cell situated near the apex of the nucleus of an ovule, which becomes more and more developed, until finally, it appears as a large sac occupying the center of the ovule.
Enchelys pupa, a flask shaped animalcule with an open, widely distended oval aperture surrounded by vibratile cilia.
Endochrome. Internal coloring matter of vegetable cells, as in Closterium, Cosmarium, etc. It consists of chlorophyll, granules of a green, red, brown, or yellowish color, protoplasm, and watery cell-sap. *Cell contents* is a better term.

Endophlœum, the internal bark of Phanerogamic plants, or liber; it consists of woody fiber, cellular tissue, and laticiferous tissue.

Endosmose, the property by which a rarer fluid passes through membranous substances into a cavity or space containing a denser fluid.

Endosperm, a peculiar albumen, or kind of parenchyma which is formed in the interior of the embryo-sac.

Ensiform, sword-shaped.

Entozoa, *s.* *Entozoon*, intestinal worms or parasites.

Epicranium, or *vertex*, the upper posterior portion of the heads of insects.

Epidermal Tissue, of plants, composed of cellular tissue, forming a continuous firm layer over the external surface of the higher plants. It is usually composed of a single layer of cells, and presents very varied appendages, as *hairs*, *glands*, etc., and is perforated by *stomates*. Its outer surface is rendered dense by the deposit of *cuticle*. The epidermis is replaced, on stems, by the *cork*, or sebaceous layer of *bark*. *Mic. Dict.*

Epidermis, the outer covering, or scarf-skin.

Epigone, the neck of the flask-shaped archegonia.

Epiphlœum, the external bark of Phanogamerous plants, likewise called the suberose or corky layer; it consists of one or several cubical or tabular layers of uncolored or tawny cells.

Epiphyte, a plant growing upon the external surface of another plant, and not imbibing any of its juices.

Episperm, the external covering of a seed.

Epispore, an external gelatinous coat of spore-sacs or sporanges.

Erector, a lens placed between the eyeglass and the objective, to reverse the inverted image seen by the eye in the compound microscope, so that its position shall correspond with that of the object. It is used, principally, in dissections, collecting of specimens, etc., under low powers.

Erose, irregularly notched, as if gnawed. *Martyn.*

Everted, turned outward.

Excipulum, the body of the apothecium.

Excurrent, (nerve of leaf); extending beyond flat surface of leaf by its apex. Any part of a plant is so called, the axis of which is central, with a uniform arrangement of the other parts around it.

Exosmose, the property by which a rarer fluid passes throu

membranous substances, out of a cavity, into a vessel containing a denser fluid.

Expando-binate, having one extremity pointed, and the other divided into two branches; when divided into three branches, *expando-ternate*, etc.

Exuvium, the cast or shed skin of animals.

Eyeglass, the glass in the eye-piece, which is next the eye.

Eyepiece, the lens or sets of lenses through which the observer sees the image of an object enlarged by the objective, and which is still further magnified by the eye-piece. Two or three eye-pieces usually accompany the best microscopes.

Eyes, of Rotatoria are termed *frontal* when they are situated in front of the esophageal bulb to which the teeth are attached; and when behind this bulb, *cervical eyes*.

F.

Falcate, curved like a scythe or reaper's hook, sickle-shaped.

Fasciculated, tufted and level topped; in groups or clusters.

Fastigiate, when the branches are parallel and pointing upward. Flat and even at the top.

Favella, among the Algæ, a berry-like external conceptaculum, with a membranous coat, closed at the apex, and containing numerous angular spores, (pl. *favellæ*.)

Favellidium, pl. *Favellidia*, a form of the conceptacular fruit of the Florideous Algæ, when the spores are collected in spherical masses, attached to the wall of the frond, or imbedded in its substance.

Fauna, the animals peculiar to any country.

Femur, the thigh of an insect.

Ferruginous, iron-rust colored.

Fibrin, is soluble in, or rendered transparent by acetic acid.

Field, *Field of view*, a term applied to the space or luminous disc on which the enlarged image of an object is apparently delineated, as seen through the eye-piece, when the focal adjustment of the objective is perfect; when the image is hazy or indistinct, or any part of it, the focal adjustment being imperfect, it is said to be "out of the field." The marginal line of the object should be clear and black; if it appear colored the eye-piece is incorrect.

Field-glass, the lens in the eye-piece next the field, or luminous

disc or space on which the image of an object is seen apparently delineated.

Filamentous, of the nature of small fibers or threads.

Filiform, thread shaped.

Fimbriated, fringed, having a fringed margin.

Finder, a small steel hand introduced in the eye-piece, which may be directed to nearly the center of the field, so as to point out any particular object or any part of it; sometimes called "indicator."

Fine Adjustment, or slow motion; the lever or screw arrangement in a microscope, by which the most delicate and perfect focal adjustment of the object glass may be made; it is more especially adapted for the higher powers. The motion of the fine adjustment is produced by turning a milled head backward or forward; it should be easily effected, be perfectly even, and should produce no apparent motion of the object. This adjustment is often attached to the stage, but the best microscopes have it to the objective itself, or the arm which carries it.

Fissile, applied to the capitate knobs of antennæ, when each one is divided longitudinally into laminæ or plates.

Fissiparous, a method of propagation by the spontaneous division of the parent into two or more parts, each of which, when separated, becomes a distinct individual.

Fissure, a little cleft.

Fistular, hollow, like a tube.

Flabella, fan-shaped bodies.

Flabelliform, shaped like a fan.

Flagelliform, tapering toward the extremity like an eye-lash or cilium.

Flexuous, bending, gently winding; leaf or stem twisted in an irregular manner.

Flexure, a bending.

Fluviatile, belonging to, or existing in fresh water rivers. *Lyell.*

Focus, the point at which the rays of light come together or converge, after having been reflected or refracted. *Newton. Barlow.*

Foliaceous, leaf-like.

Foramina, holes or perforations in the siliceous frustules of diatoms, situated along the line of suture in-
cular frustules, but more generally at the
valves only. *W. Smith.*

Foraminifera or *Polythalamia*, Rhizopods covered with a calcareous shell which is perforated with minute apertures or foramen, and divided by septa into several chambers.

Foraminous, perforated in many places, full of holes, porous. *Bacon.*

Fosses, ditch-like depressions or cavities.

Fossulæ, little fosses.

Fovilla, a fine granular substance emitted from the pollen of flowers. *Martyn.* It exhibits an active quivering motion, called the "molecular motion." Fovilla appears to consist of granules of protoplasm, minute globules of oil, and starch grains.

Frondlet, a little frond.

Frondose, like a cryptogamic plant, that has no leaves distinct from the stem.

Frond, a term applied to those ferns, sea-weeds, and other plants, whose stalk and leaves are so intimately connected, that it is difficult to determine where the one ends or the other begins; (*Milne*) it signifies all parts of the plant except the root; the leaf-like appendages of cryptogamic plants.

Frustules or *Testules*, the joints of which dichotomous plants are composed; the component cells of diatomaceous plants, each cell or frond is called a frustule, and includes the silica and organic matter in the individual specimens; thus, the frustules of Arachnoidiscus are free, and consists each of two valves or plates,—while the frustules of others, as Achnanthes, are adherent to each other, forming a chain or succession of frustules, each frustule also consisting of two valves; sometimes frustules are held together, or attached to other plants, stones, etc., by a stipe or stalk-like appendage. The front of a frustule is seen when its suture or line of fracture between its valves is turned toward the eye; when the center of either valve is directly beneath the eye, a side view is obtained.

Fucaceæ, a genus of Algæ, or sea-weeds. *Encyc.*

Fuliginous, smoke-colored.

Fungi, a division of cryptogamic plants, as mushrooms, toadstools, smut, mold, mildew, yeast plant, sarcina, etc.

Funiculus, the base of the ovule pushed up from the surface of the placenta during its development, so as to appear supported on

a stalk of variable length; this stalk is attached to the body of the ovule at its hilum. A small cord or fiber.

Furcate, divided at the end into two prongs or branches, like a fork.

Fuscous, reddish-brown.

Fusiform, spindle shaped, small at the two extremities, and thick in the center.

G.

Galea, or helmet; the extremity of the lobe of the palpus.

Ganglion, a knob or mass of nervous matter occuring along the course of a nerve, or from which the nerve radiates.

Gasteropoda, an animal having the foot and belly united, forming a fleshy organ by means of which it moves, as in the common slug, *Limax rufus*, shelless snails, common whelk, rock-whelk, etc.

Gelatinoso-cartilagionus, between gelatinous and cartilaginous.

Gelatinoso-membranaceous, between gelatinous and membranaceous.

Gelatinous, composed of jelly-like substance.

Geminate, to double; to grow in pairs; teeth of peristome arranged in pairs.

Gemmæ, rudimentary buds, imperfect buds, corresponding to the *buds* of flowering plants, and the *gonidia* of Thallophytes.

Gemmation, the process of reproduction by detached cellular structures or imperfect buds independently of the spores.

Gemmules, little buds, growing upon the bodies of infusoria, etc., forming new bodies.

Geniculated, bent so as to form a knee or angle, bent like the knee.

Germ Cells, see Sporangial cells.

Gibbous, ***Gibbose***, having one or more large elevations; *Brande;* the surface elevated at a particular place; bulging; projecting.

Glabrous, having a smooth surface.

Glandular, having glands; bodies containing juices.

Glass Covers, squares or discs of glass with which to cover cells and microscopic objects; they are [illegible] of thin unannealed glass varying from $\frac{1}{20}$th to $\frac{1}{200}$th of a [illegible] Great care is required in handling and cl[illegible] break very readily.

Glass Slides, the slides employed for m[illegible]

made of "flatted crown," or "plate glass," and measure three inches by one inch. Occasionally they are met with larger or smaller. Glass slides, as well as thin glass covers, may have any greasiness removed from their surfaces by soaking them in a strong infusion of nut-galls, then cleansing them with clear water. The slides may be had of Messrs. Heroy, Struthers & Co., No. 42 Cliff St., N. Y., for $3 per gross.

Glaucous, mixture of green and blue; sea-green color. *Lindley.*

Gleba, fleshy sporiferous mass, on the convolutions of which, spores are developed.

Globule, a minute particle of matter having a globular form.

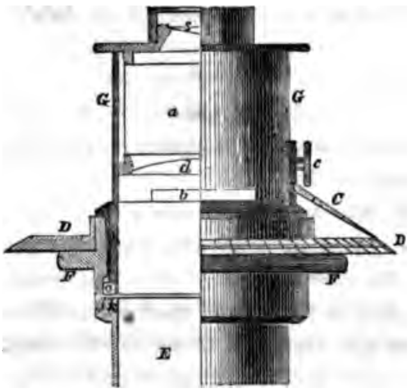
Globuline, an amorphous animal substance nearly allied to albumen, existing within the colored corpuscles of the blood and the crystalline lens. *Mic. Dict.*. It is a protein body.

Glutinous, gummy and cohesive like glue.

Gonidia, (*s. gonidium.*) globular gemmule cells of lichens, etc., filled with green matter, and which cells are capable of reproducing the plant, when detached. They contain the multitude of granular particles or spores formed by the subdivision of endochrome; these are liberated by the bursting of the cell wall, those with cilia and active locomotion are called "Zoospores," or, when they have not this power, remaining still, they are termed "resting spores."

Goniometer, a graduated instrument, attached to the eye-piece of a microscope, for the purpose of measuring the angles of crystals. *Wollaston.*

Fig. 96.

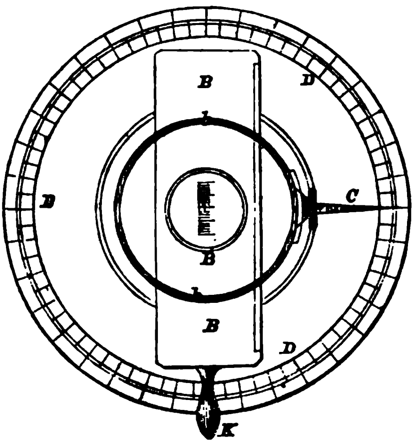


Prof. J. Lawrence Smith has invented a Goniometer for measuring angles under the microscope, which is described as follows in the American edition of "Carpenter on the microscope, by F. Gurney Smith, M. D., Philadelphia, Blanchard & Lea, 1856. The instrument is attached to the chemical microscope of the Messrs. Grunow & Co., though it may be fitted to any microscope.

"*E* is the upper end of the draw tube of the microscope, with the ring *k*, soldered to it. (*See fig.* 96.) Over this ring *k*, screws another ring *F*, which serves as a support and as a center to the graduated circle *D*, which freely, but without shaking, revolves upon the same. Into the bore of the ring *F*, fits by its lower conical end *h*, the tube *G*, which is held in it by a screw-ring *y*, that prevents its being taken out. Into the tube *G*, which also has a free revolving movement, fits the positive eye-piece *a*, *d* being the field-lens, *s* the eye-lens. The slide *b b*, on opposite sides of *G*, admits of the micrometer with its mounting *B*, *B* being introduced into *G*, and the graduation being brought into the field of the eye-piece. *C* is an index, attached to *G*, by the screw *c*; it may be taken off when the apparatus is not used as a goniometer."

To use it,—" Bring the object into focus near the center of the field of the micrometer, apply your finger to the knob *K*, and revolve the micrometer, till the lines of its graduation are parallel to one side of the angle to be measured. Revolve then separately the graduated circle, till zero is brought to agree with the point of the index *C*. Then revolve again the micrometer by the knob *K*, fig. 97, until the graduation lines are parallel to the other side of the angle to be measured, when the index *C*, will show the value of this angle. (The references are the same in both cuts.)

Fig. 97.



" The graduated lines of the micrometer, are generally $\frac{1}{200}$ of the American inch apart. But their relative value as micrometer, with the different object-glasses and eye-pieces, must be ascertained by a glass stage-micr[illegible] in a table." [I am indebted to the kin[illegible] the editor of the American edition o[illegible] scope," for the preceding extract fr[illegible]

a work which should be found in the library of every microscopist.]

Gorgonia. These are a family of coral-zoophytes, which are flexible, and seem like plants growing from the rocks to which they are fixed. They consist of a central, branched, horny, and sometimes anastomosing flexible axis, coated with a soft and fleshy polypiferous crust. They dwell in deep water, but display their colors more beautifully in shallow water. The stems are of various shapes, and the soft flesh when dried is earthy and friable, containing carbonate of lime. Sponge, red-coral, sea-fern, etc., belong to this family, which is not microscopic, as the corals are often very large.

Grammatophora, a genus of diatomaceous plants, in which the transverse striæ or lines are exceedingly delicate, requiring an object glass of good resolving and defining power, and with large angular aperture, to render them visible; the frustules, when presenting a front view are traversed by bands, generally sinuous, which are called "vittæ." There are several varieties, the valves of some which are difficult tests for good objectives of high power, as the *G. Subtilissima.*

Granular Swarm, the swarming or accumulation of granules or particles, (gonidia or zoospores,) *in motion*, and bearing some resemblance to a swarm of bees; they may be seen in Cosmarium, and in the large rounded space which is left at each end of the cell of Closterium, within its frond.

Granulated, covered with granules or little grains.

Granule-cells, cells of new formation found in animal solids and liquids, containing a number of globules of fat or oil, as in cancer, inflammation, etc. They are of variable size, are easily recognized by the dark margins and light centers of the globules, which are insoluble in acetic acid and solution of potash. The cells sometimes contain a nucleus, at others not. *Mic. Dict.*

Granules, minute grains or particles of matter; seeds in the form of little grains, called sori collected in patches on the frond, or placed in the tips of branchlets. Capsular seed is called *primary*, and granular seed *secondary*, only by way of distinction, for they are equally productive of plants.

Gregarious, being together in flocks or companies.

Griseous, white mottled with black or brown.

Growing Slide, a slide of glass five inches by two, having an aperture at one end, in which is fitted a small cup or test tube, about three quarters of an inch deep, with a notch in one part of its rim, and which is covered by a cork cemented to a plate of glass; along the length of the slide, and toward its edge, a small strip of glass is cemented, to form a ledge and prevent objects from sliding off. When it is desired to preserve animalcules for a length of time under examination, or follow the changes undergone by some microscopic plant, the ordinary glass slide, holding the object, is placed upon the growing slide, the little cup of which is filled with water proper for the object,—in this one or two threads of lamp cotton are placed, passed through the notch in its rim, and one end carried to the edge of the thin cover on the object; as the water evaporates from beneath the thin cover, the threads will afford a constant supply, so long as there is any fluid in the cup, and which may require to be refilled from time to time. *Mic. Dict.*

Gula, the inferior posterior portion of the heads of insects.

Gymnostomous, mosses are so called when the mouth of the sporange is naked, without teeth.

H.

Habitat, the natural place of permanent abode of any organic body.

Halteres, balancers or poisers, two short movable appendages placed near the origin of each wing, and are peculiar to the two winged insects.

Hamiform, curved at the extremity like a hook. *Hamulous*, hooked.

Hastate, shaped like a spear.

Haustellium, a proboscis or sucker of insects. *Haustellum.*

Helianthoida, a class of zoophytes, whose polypes bear many rows of tentacula, the latter being in abundance; they strongly resemble a sunflower.

Helical, spiral, like a helix, coiled spirally.

Heliopelta, sun shield, a very beautiful diatom found in the Bermuda earth, having eight radial divisions, four alternate ones presenting circular areolæ, the other four a minute granular constitution.

Hemelytra, or *demi-elytra*, horny or leathery anterior wings, but membranous toward the summit, as in wood-bugs.

Herapathite, plates or laminæ of iodo-sulphate of quinia, prepared for polarizing light, first made by Dr. W. B. Herapath, of London. They have not yet been made large enough to supplant tourmalines or Nicol's prisms. Fifty grains of pure disulphate of quinia are dissolved in two fluid ounces of strong acetic acid of sp. gr. 1.042, mixed with proof spirit two fluid ounces; the solution is now heated to 130° F., and fifty drops of the tincture of iodine must be immediately added in drops, the mixture being constantly agitated. The tincture of iodine is to be made by dissolving forty grains of iodine in one ounce of rectified alcohol; and the proof spirit used must be made of equal parts of rectified alcohol, sp. gr. 0.837 and distilled water. The compound should be prepared in a wide mouthed Florence flask or matrass; and the temperature should be maintained for a little time after the addition of the iodine, so that the solution should become perfectly clear, and of a dark sherry color. It should then be set aside to crystallize in a room of a uniform temperature of 45° to 50° F., and be kept from vibration. This may be effected by suspending the flask by the neck with strong string, attaching this to a horizontal cord stretching across the room from one wall to the other; or by placing the flask on a steady support, lying upon a pillow.

The large crystalline plates form upon the surface of the liquid, where they are allowed to remain for twelve to twenty-four hours, until they have acquired sufficient thickness. The flask is then carefully removed without shaking, and rested upon a gallipot. A circular thin glass cover is then fastened by its edge to the end of a glass rod with a little wax or marine glue, and carefully passed beneath one of the crystalline films; the adherent mother liquor is cautiously removed with blotting paper, and without touching the crystal, which is then allowed to dry in a room at a temperature of 45° to 50° F. The cover and film are then placed under a cupping glass, or a small bell-glass, with a watch-glass containing a few drops of tincture of iodine. The time required for the iodizing may be about three hours at 50° F., or less if the temperature be higher.

The film is then mounted by covering it with a solution of Canada balsam in ether saturated with iodine, by warming it

with a few crystals of this substance, and allowing it to cool. Other films are removed and mounted in the same manner.

Should the films not separate from the original liquid at the end of six hours, this must be heated with a spirit-lamp until the deposited crystals are dissolved, a little spirit and a few drops more tincture of iodine be added, and the liquid again be set aside.

If the film appear black when removed on the cover, it is crossed by an adherent or interposed crystal, which must be carefully removed.

These crystals are an iodo-disulphate, or a sulphate of iodo-quinia; they are of a pale olive-green color, and possess a more intense polarizing power than any other known substance. The play of colors they present when rolling over each other in a watch-glass, forms a beautiful sight, the colors varying according to the relative position of the crystals to each other; and when the latter cross each other, at a right angle, complete blackness is produced.

They are so easily decomposed and altered that they are with difficulty mounted. This may, however, be effected by cautiously neutralizing the excess of acid in the mother-liquor by solution of ammonia, taking care not to precipitate the excess of the disulphate of quinia; a portion of the liquid containing the crystals is then transferred to a slide, the liquid removed with blotting paper, and the crystals dried in a current of cold air. They are then mounted in Canada balsam rendered thin with iodized ether, heat being avoided. *Mic. Dict.*

Hexapods, animals with six feet.

Hilum, or *Nucleus*, a kind of scar seen on the surface of attachment of the funiculus of seeds; sometimes it coincides with the chalaza or organic base of the seed; sometimes, where a raphe exists, it is near the micropyle. *Mic. Dict.*

Hipparchia Janira, the meadow brown butterfly, having brown rounded wings, with a blackish brown round spot having a white center on the anterior pair. The scales are used as test objects.

Hippocrepia, horse-shoe like fresh water polyzoa.

Hirsute, thickly set with long stiffish hairs, shaggy.

Hispid, beset with bristles or stiff hairs.

Histology, science of the tissues, or of the minute structure of the organs of animals and plants.

Huyghenian eye-piece, an eye-piece consisting of two plano-convex lenses, with their plane surfaces toward the eye; these are the eye-pieces usually accompanying microscopes. It is sometimes called the "negative eye-piece." See fig. 111, on page 6, and explanation on page 27.

Hyaline, pellucid, glassy.

Hydatina, a variety of the Rotifera or wheel-animalcules.

Hydra, a fresh water polype, found in pools and ditches, and on the radicles of duck-weed, and which has the remarkable property, when cut up into parts, of forming as many hydræ, as there were sections of the original one. *H. viridis*, green polype; *H. vulgaris* yellowish, red, or orange-brown polype, etc. They afford much interest to the microscopist.

Hydrozoa, fresh water polypes.

Hymenium, the term applied to the layer of cellular tissue upon which are seated the basidiospores of the higher Fungi. *Mic. Dict.*

Hymenophore, the central fleshy column of the gleba in fungous plants, as in Poxadinei.

Hymenoptera, the wasp and bee tribe; a class of insects characterized by four naked membranous wings; the abdomen of the females terminates by a sting, or ovipositor.

Hypothallus, the under surface of lichens.

Hypothecium, a special layer of cellular tissue, lining the apothecia of Lichens, and which bears the thecæ, and the paraphyses.

I.

Illoricated, not having a carapace or hard cover of horn, or silex, etc., as when animalcules are naked or shell-less, they are said to be illoricated.

Illumination. In addition to what has been said in the first part of the work relative to illumination or giving sufficient light to observe objects clearly and distinctly under the microscope, the following observations by James Smith, and taken from the first volume of the Microscopic Journal, will be found useful: "Much of the beauty of the objects seen depends upon the management of the light that is thrown upon or behind them; which can only be fully mastered by practice. In viewing

transparent objects, as a general rule, the plane mirror is most suitable for bright daylight; the concave for a lamp or candle, which should have the bull's-eye lens, when that is used, so close to it that the rays may fall nearly parallel on the mirror; if this lens be not used, the illuminating body should not be more than five or six inches from the mirror. It will be seldom required to have the mirror more than three inches from the object, the details of which are usually best shown when the rays from the mirror fall upon it before crossing, and the center should (especially by artificial light) be in the axis of the microscope. For obscure objects, seen by transmitted light, and for outline, a full central illumination is commonly best; but for seeing delicate lines, like those on the scales of insects, it should be made to fall obliquely, and in a direction at right angles to the lines to be viewed.—The diaphragm is often of great use in modifying the light, and stopping such rays as would confuse the image, especially with low or moderate powers; but many cases occur when the effects desired are best produced by admitting the whole light from the mirror.

"If instead of the diaphragm, an achromatic condenser be used, its axis should correspond with that of the body of the microscope; and its glasses, when adjusted to their right place, should show the image of the source of artificial light, or, by day, that of a cloud, or window-bar in the field of the microscope, while the object to be viewed is in focus.—The most pleasing light for objects in general, is that reflected from a white cloud on a sunny day; but an Argand's lamp, gas-light, or wax candle with the bull's eye-lens, (and a neutral tint glass on the stage) is a good substitute."

For opaque objects, the Lieberkuhn is very useful,—but the best microscopists use the bull's eye condensing lens for throwing the light upon the object placed on a black ground.

Imago, a perfect insect, having completed its metamorphosis.

Imbricated, lapping over each other like the shingles on a house.

Inarticulate, without joints.

Incident light, rays of light falling directly upon an object.

Incrassated, thickened in any part; larger toward the end.

Incubous, leaves are so called, when each leaf overlaps a little of the base of the leaf above it, as in the Hepaticaceæ.

Incurved, bent inward.

Indicator, a graduated stage or instrument, by means of which an object mounted on a glass slide may at any time after its position has been found, be at once brought into the field of view without any delay, whenever it is desired to examine it. *See fig.* 40.

Indusium, a delicate membrane on fronds forming a sort of a cap or cup upon the summit of each sorus.

Inflected, bent inwards; not proceeding in a straight line.

Inflection, see Diffraction.

Infundibulate Polyzoa, funnel-shaped marine insects.

Infusoria, certain microscopic animalcules found in water and infusions of organic matter. They appear to possess no vessels nor nerves, but exhibit internal spherical cavities, and move by cilia or variable processes formed of the substance of the body. They generally increase by simple division, or by gemmation from the surface. Infusoria are extremely interesting subjects both for the curious and scientific.

Injections. For the purpose of examining the capillary blood-vessels of the system, as well as other minute tubular organs, the transparency of whose walls are such as to render them almost invisible, or prevent them from being distinguished from the tissues surrounding them, it is customary to fill them with some colored preparation, which will bring them distinctly into view, so that the observer can determine their size, arrangement, and relation to the neighboring parts. The mode by which this result is accomplished is called *injecting*, and the objects thus prepared, are called *injected preparations*. These are of two kinds; natural, when obtained from the dead animal without any preparation whatever, the capillaries being gorged with blood, and thus rendered distinct; artificial, when they are filled with some coloring substance by means of a syringe. Injected preparations form beautiful objects for the microscope, but are very difficult to prepare, requiring considerable practice as well as some anatomical knowledge; and, as a general rule it is better to obtain them already made by those whose business it is to prepare them.

The instruments required for making injections are, 1. *Syringes*. Two or three injecting syringes capable of holding half an ounce, an ounce, and two ounces, according to the volume of injecting material to be thrown into the vessels, will be required.

It is unnecessary to enter into a description of these syringes here; excellent ones are manufactured by M. Charriere of Paris, Mr. Neeves, or Mr. Ferguson of London, together with all other necessary apparatus, and they may be obtained through the houses of H. Bailliere, N. Y., Robert Clarke & Co., Cincinnati, McQueen, Phila., etc. Every syringe should have a small stop-cock fitted to it for the convenience of its being refilled without the chance of any of the injection escaping from the vessel into which the pipe is inserted. Each syringe should also be furnished with several *pipes* of various sizes to fit the vessels into which they are to be inserted. When these get clogged up, they may be cleaned by passing a very fine wire down them, or by boiling in water. The tube of the smaller pipes should be made of silver. Small conical shaped *corks* are also required, with which to plug up the pipes while the syringe is being refilled. Every time a syringe is used it should be taken to pieces, and all parts thoroughly cleaned; and should be placed separately, if possible, in the box where it is kept, to prevent any parts becoming fixed together by oxidation. To clean greasy portions, spirit of turpentine is used; for others hot water or alcohol, according to what has been used as the vehicle of the injection.

2. *Brodie's artery forceps* for stopping up any vessels through which the injection may escape accidentally; several pair of them should be provided. 3. A *needle*, somewhat like an aneurism needle, for passing the thread round the vessel to tie it on the pipe which is inserted into it; it should not be too large. The thread used should be silk, strong, and not too thin, lest it cut through the vessels.

The injection should be commenced at a period after death varying with the kind of organ or tissue; if it be delicate the sooner the better; while if the vessels be comparatively large by some little delay the tissue becomes somewhat softer and more yielding. A large vessel communicating with the smaller ones [illegible] is to be injected [illegible] is selected, the pipe [illegible] into it and [illegible] after which all other vessels communicating with it should be tied around with silk thread or closed in some other way that the injection may not escape. [illegible] [illegible] [illegible] [illegible]

the tissue at the spot from which the injection might escape, by the application of a red-hot iron. The part to be injected is then placed in warm water, and as soon as it has become warmed throughout, the injection, warm and in a fluid state, is forced in by means of the syringe. Care must be taken that no air be allowed to enter, and the pressure made upon the piston must be gentle and continued gradually, so that none of the vessels may become ruptured. A considerable escape of the injection is often unavoidable, and must not be heeded; when it is very great, it may be checked by one of the means above named.

As soon as the injection is completed, a ligature should be placed around the vessel into which the pipe is inserted beyond its nozzle; the pipe is next removed, and the preparation placed for an hour or two in clean cold water. It may then be withdrawn, and sections made of it, with a knife, razor, or other instrument.

Injections may be preserved either in the dry or wet state. For the former, sections should be made, thoroughly dried upon slides, then moistened in oil of turpentine, and mounted in balsam. For preservation in the wet state, they must be mounted in cells while immersed in dilute spirit, Goadby's B solution, or in a solution of chloride of zinc.

Injections are either opaque or transparent. In *opaque* injections, parchment size or gelatine is used as the material in which the coloring matter is suspended. It must be melted in a water bath, and strained immediately before use. The size should be of sufficient strength to form a tolerably firm jelly when cold, and a perfectly limpid fluid when warm, which will flow readily into the most minute vessels.

Gelatine forms an excellent substitute for size, especially when it has to be carried a long distance. An ounce of gelatine to a pint of water will be sufficiently strong, but in very hot weather a little more gelatine will be necessary. It should first be soaked in cold water until it swells up and becomes soft, when it may be dissolved by the aid of heat. If sufficient gelatine has been dissolved in the water, a drop of the solution placed upon a cold surface will become solid in a few minutes.

The coloring matters, should always be prepared immediately before use, being reduced to a minute state of division before

they are added to the size; there should be plenty of coloring matter in the size, which should be well mixed with it, and the mixture strained through muslin immediately before use. For *red*, Vermilion or Carmine may be used; the former makes the best specimens for reflected light. *Blue*, Indigo, Prussian Blue or Smalt. *Yellow*, Gamboge, Indian yellow. *Green*, Verdigris, *Black*, Lamp-black.

For *red*, vermilion is decidedly the best coloring substance, about an ounce and a half of which may be added to a pound of size. For *yellow*, chromate of lead (chrome yellow) has been preferred; or it may be prepared as follows; dissolve 100 grains of acetate of lead in four ounces of size, warmed, and then add, of each, finely powdered, Bichromate of Potash 76 grains, Carbonate of Potash 41 grains. Or, Acetate of lead 190 grains may be dissolved in warm size, 4 ounces, and then add neutral Chromate of Potash 100 grains.

The best *white* injection is made with carbonate of lead, thus: take of Acetate of lead 190 grains, dissolve it in warm size 4 ounces, and filter; dissolve carbonate of potash 83 grains in the smallest possible quantity of water, and mix it with the size.

Blue injections are not to be recommended, for blue pigments reflect so little light, that the injections made with them, appear almost black. The best preparation is made by finely triturating oxalic acid 73 grains, in a mortar, then adding Prussian blue 73 grains together with a little water; and then mix the whole with warmed size 4 ounces.

All these injections may be preserved in the state of jelly, by keeping a film of rather strong alcohol on their surfaces; when wanted for use, the alcohol must be poured off, and the surface of the jelly having been well washed with cold water, it is to be melted by a gentle heat.

Transparent injected objects are frequently prepared. Several different substances may be used in injecting these, as glue size, or equal parts of gelatine and glycerine. A red transparent injection may be made by adding a little liquid ammonia to some carmine, and diluting the mixture with size, or other fluid, until the proper color is obtained.

A *blue* transparent injection may be made by dissolving twelve grains of ferrocyanide of potassium in a half ounce of

water; likewise adding one fluidrachm of muriated tincture of iron to another fluid ounce of water. The iron solution must be very gradually added to and mixed with the potash solution, and be well shaken in a bottle. When thoroughly mixed, a dark blue mixture should be produced, without any flocculi or precipitate. Next, add a fluidrachm and a half of wood naphtha to an ounce of alcohol, to which must be subsequently added glycerine one ounce, and water two ounces. Slowly mix this colorless fluid with the Prussian blue previously made, and shake the whole thoroughly together during the admixture.

Insects may be injected by making a small opening into the abdomen, and forcing the injection into the general abdominal cavity, whence it passes into the dorsal vessel, and is afterwards distributed to the system. Indigo triturated with oil, and diluted with oil of turpentine, may be used as the injection; or, a solution of alkanet in oil of turpentine. The vessels of fishes are exceedingly tender, and require great caution in filling them. It is often difficult or quite impossible to tie the pipe in the vessel of a fish, and it will generally be found a much easier process to cut off the tail of the fish, and put the pipe into the divided vessel which lies immediately beneath the spinal column. Beautiful injections of fish may thus be made.

The vessels of Mollusca, snails, slugs, oysters, etc., are so thin and soft as to frequently render it impossible to tie the pipe in the usual manner. The capillaries are, however, usually very large, so that the injection runs very readily. In different parts of the bodies of these animals are numerous lacunæ or spaces, which communicate directly with the vessels. Now, if an opening be made through the integument of the muscular foot of the animal, a pipe may be inserted, and thus the vessels may be injected from these lacunæ with comparative facility. *L. Beale. Mic. Dict.*

Inosculation, the union of two vessels at their extremities; anastomosis. *Ray.*

Insects, the smaller and more delicate insects, aquatic larvæ, [illegible] are best preserved in solution of chloride of calcium, [illegible]ine, mounted in suitable glass cells. To preserve [illegible] the future examination of the internal structure, [illegible] kept in solution of chloride of zinc; but when very [illegible] fragile, they may be kept in spirit and water. *Mic. Di*[illegible]

Integument, natural covering of a body, as the skin.

Intercalated, placed between; set in.

Interstice, the space between elevations and depressions; a small interval between things in approximation.

Interstitial, belonging to, or having interstices.

Intervertebrate, destitute of a backbone.

Inulin, a substance resembling starch, found in some of the Compositæ. It does not contain so large a proportion of the elements of water, as starch, and is colored brown or pale-yellow by iodine. *F. Currey.*

Involucre, a small cover of fruit formed of short branchlets; a kind of calyx surrounding umbellate flowers.

Involute, rolled inward.

Iridescent, having colors resembling the rainbow; presenting the prismatic colors.

Isis, calcareous and jointed.

Isochronal, coincident, simultaneous, or equal in time; having equal times.

Isthmi, stalks or connective pedicels.

Isthmia, a diatom found on sea-weed, etc., the frustule of which is supported at one angle on a footstalk, and the whole of which is areolated. Isthmia obliquata is found on sea-weed in the neighborhood of Boston, Mass.

J.

Juncture, a joint or articulation.

K.

Keel. Carina. The lower petal of a papilionaceous corol, enclosing the stamens and pistil. *Martyn.*

Knobbed, having knobs, protuberances, or tubercles.

L.

Labial, belonging to the lip or lips.

Labium, a lip; the lower l[illegible] sects.

Labrum, a lip, the [illegible]

Lacerna, a [illegible]

Lacinia, fring[illegible]

Laciniated, [illegible] fringed.

Lacuna, [illegible]

17

Lacustrine, natives of fresh water (or lakes.)

Lamellated, divided into layers or plates.

Lamelliform, formed like a plate or scale. *Jour. of Sci.*

Lanceolate, tapering to a point like a lance.

Larynx, the upper portion of the windpipe.

Larva, the first stage after the egg in the metamorphosis of insects; the grub or caterpillar state. *Linn.*

Lateral, at the sides.

Latex, milky juice of plants.

Laticiferous tissue, *ducts*, *canals*, or *vessels*. The tubular canals, in which is contained the *latex* or milky juice of many plants; these canals are often ramified.

Latticed, in open squares like net-work.

Lemna, Duckweed. A genus of aquatic Monocotyledonous plants, which bear two monœcious imperfect flowers. The leaves or fronds are two or three in number and float upon the water, while the roots hang loosely down in it, as in the *Lemna Trisulca*, or Ivy-leaved Duckweed. During the warm summer months numerous animalcules, polypi, etc., will be found upon them or in their neighborhood.

Lenticular, like a lens, with a round circumference, surface convex above and below.

Lepidoptera, butterflies and moths; an order of insects characterized by four large, extended, membranous wings, covered above and below with numerous small imbricated scales, which to the naked eye resembles a quantity of flour-like dust scattered over them; with a long tube-like mouth or proboscis, coiled up spirally, and two antennæ of variable form.

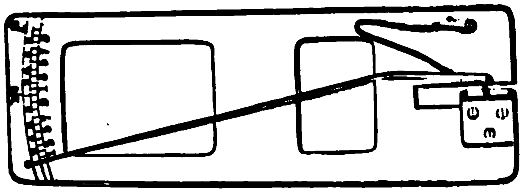
Lepisma Saccharina, an elongated, flattened, active, and nocturnal insect, called sugar louse, small book-worm, window fish, etc., with setaceous antennæ, and three long filaments projecting from the extremity of its abdomen. Its body is covered with beautiful silvery scales, the longitudinal ribbings on which afford "test objects," for the lower powers, as the $\frac{1}{4}$ in., 1 in., and 2 in., objectives.

Lernæa, *Lernæans*, a family of the lower forms of crustacea, some of which having a sharp, long head with which they pierce the surface of fishes and other animals infested by them. They are parasitical.

Lever of Contact, (*see fig.* 98) for measuring the exact thickness

of any piece of thin glass used as covers. This Lever is the invention of Mr. A. Ross, of London. It consists of a plate of brass, with or without legs, which has attached upon its surface near one of its extremities a movable lever. The lever is

Fig. 98.



quite thin, is made of steel, moves on a pivot, and has a small, bevelled, straight-edged protuberance, which, by means of a spring behind the lever, is brought close against a vertical plate of steel, at a point corresponding to the *—this vertical plate is attached to the brass one by screws. At the other extremity of the brass plate is a graduated arc, each division of which is equal to the $\frac{1}{1000}$th of an inch, when used as about to be described. The free end of the moveable steel lever is made to pass over this arc to such extent as may be required when measuring a thin glass cover. Its mode of use is as follows, the thin glass is to be placed between the bevelled protuberance at the joint of the lever and the vertical plate; the spring presses all closely together, and the degree of separation between the protuberance and the plate, as ascertained by the graduation to which the free end of the lever points, is the measurement of the thickness of the glass. Thus if the lever points to 10 on the scale, the thickness is ·001 or 1 1000th of an inch; if it points to 6, the thickness is ·006 or a little over 1 [illegible]th of an inch. The "pivot-gauge" used by watchmakers is less expensive than the preceding instrument, and may with very little trouble be so arranged as to answer equally as good a purpose. Another mode of determining the thickness of any piece of glass, is to hold it edgewise to the objective by means of the stage-forceps, and then with a low power and the micrometer eye-piece, measure the thickness of its edge.

Lever Stage, a microscope stage movable in all directions by means of a l

Lichens, are cryptogamous plants, usually growing upon the limbs or trunks of trees, on rocks, hard earth, and other places where there is a free supply of light and air, but a scarcity of moisture; as, Iceland moss, and some of the liverworts.

Lieberkuhn, a concave speculum attached to objectives for the purpose of illuminating opaque objects, or objects upon a dark field, by reflecting the light from the plane mirror of the microscope down upon them; not much used at present.

Lignine, a modified condition of cellulose obtained from old wood cells. It differs in its reactions from pure cellulose, being colored yellow by sulphuric acid and iodine, but after boiling in nitric acid and washing, tincture of iodine and water give it a blue color. *Mic. Dict.*

Lignite, fossilized wood; a kind of coal.

Ligula, the tongue or proboscis of Coleopterous insects, also "Columella," *which see.*

Ligulate, in the form of a tongue or strap.

Limbus, a border.

Linear, in botany, when the two sides are parallel; narrow; the same width all along; consisting of lines; marked with lines.

Linear Measurement, the simple measure across; the measurement of a magnified object in diameters; thus, if one square be magnified four times its size in length, its linear measurement is four, or four diameters; but this square is magnified four times in length and also four times in breadth, giving sixteen squares, or a magnifying power of sixteen times, which is called its superficial measurement. The magnifying power of microscopic objectives is always given in diameters, or by linear measurement.

Lingua, proper tongue of insects.

Linguliform, tongue shaped.

Lirellæ, the open apothecia of Gymnocarpous Lichens, in the form of irregular cracks or lines, with raised borders.

Littoral, a native of, or pertaining to the shore.

Lobed, having lobes, or broad finger like divisions.

Loculated, divided into cells.

Loculi, (*s. Loculus*,) pollen chambers in which the pollen-grains originate.

Lophophore, the annular disc to which the contractile and tentacula of Polyzoa are attached; it is perforated and

the superior wall or covering of the visceral or perigastric cavity.

Loricæ, the hard or horny covering of diatoms and animalcules. The term *Carapace* is more commonly applied to the latter.

Loricated, having a lorica.

Lunated, in the shape of a crescent.

Lymneus Stagnalis, the common water snail.

M.

Macrogonidia, a larger form of ciliated zoospores in Confervoid plants; their motion lasts about half an hour; from 7,000 to 20,000 occur in one cell, each possessing four *short* cilia. *Mic. Dict.*

Macrourous, long tailed.

Madrepores, a family of coral zoophytes with spreading branches like plants; instead of the external surface of their skeletons being smooth like other corals, it is rough with small cells in which the animal lives. *See Coral.*

Magnetic slide; two slips of thin brass plate, being each an inch in length and half an inch in width, and having a round or square groove cut upon the surface and along the center of each in its long diameter, are attached to a glass slide, by means of marine glue, or other cement. These slips are to be placed, [with their grooved surfaces in contact with the plane surface of the glass slide,] one on each extremity of the slide, with their long diameters running along the center of the slide and in the direction of its long diameter, thus leaving the space occupying the *central square inch* on the surface of the slide, free, for objects to be placed upon for examination under the microscope. The grooves on the brass slips, as well as that part of the surface of the slide opposed to them, must be kept clean and free from cement or other matters. In each of these grooves, a piece of round or square copper or other metallic wire, about two inches in length, is nicely fitted, so that it may move in and out freely but not too loosely; one end of each wire is [illegible] to a point, which must rest in actual contact [illegible] slide, while the other end is to be [illegible] attachment of conducting wires [illegible] lide the action of electricity, [illegible] n animalcules, or other

objects, may be observed under the microscope with any magnifying power.

To use it, place the slide with the object upon it, on the stage of the microscope, and, to the rings of the wires moving in the grooves, attach the conducting wires of a battery; move the wire in the left hand groove so as to bring it in contact with the object or fluid containing it, and then arrange the focus of the microscope that the magnified image of the object may be seen distinctly, the glass slide being held stationary by the stage clips or otherwise,—then, while the eye is observing the magnified image of the object, slowly advance the wire in the right hand groove until the required connection is made. Instead of having the end of the copper wires pointed, they may be made broad and flat, toothed, etc.; and various additions may be made for very delicate experiments.

Magnifying Power, the dimensions, or measure of the size of an enlarged image presented to the eye, as compared with the natural size of the object itself; the angle subtended by an object or image at the eye of the observer. *See Visual power.*

Malacopterygian, fishes that have no bony fin-rays are so termed. Soft finned.

Mammillated, studded with little projections, globes, or warts, like nipples.

Mandibles, a pair of jaws; the upper or anterior pair in insects. *Brande.*

Mantle, the external fold of the skin of molluscs, which covers the viscera, and a great part of the body, like a cloak.

Manubrium, pl. *manubria*, an elongated cell in Algæ, next to the globular basal cell.

Maxillæ, true jaws of insects; they are two in number, and not so strong nor so large as the mandibles, below and behind each of which, one is placed; they serve to carry the food to the back part of the mouth.

Meandrina, a family of corals with winding or meandering cells, as the brain-stone coral. *Mantell.*

Medial, *Mesial*, placed in the center or middle.

Meniscus, a lens concave on one side and convex on the other, having the convexity larger than the concavity. *Olmstead.*

Mentum, the chin.

Merenchyma, where the cells of the parenchyma or cellular tissue are round, oval, etc.

Meridion Circulare, a beautiful diatom found in the mountain brooks about West Point.

Mesophlœum, or "cellular envelope" of Phanerogamic plants; the middle bark lying between the endophlœum, and the epiphlœum; it consists of loose, prismatic cells, commonly green, with cellular canals between, called "laticiferous canals."

Mesonotum, the posterior or dorsal half of the mesothorax.

Mesosperm, the membrane in seed next to the outer one.

Mesosternum, the anterior or sternal half of the mesothorax.

Meso-thorax, or *medio-pectus*, the second ring of the thorax in insects.

Metanotum, the posterior or dorsal half of the metathorax.

Metasternum, the anterior or sternal half of the metathorax.

Metathorax, or *post-pectus*, the third ring of the thorax in insects.

Microgonida, antheridial cells, zoospores, or minute bodies, in Confervoid plants, but longer shaped than the macrogonidia; from 30,000 to 100,000 appear in the parent cell; they escape from the cell in a swarm, swim about freely in the water for a long time, and at length sink to the bottom, where they rest, heaped in green masses; each body is furnished with four *long* cilia and a red parietal spot. *Mic. Dict.*

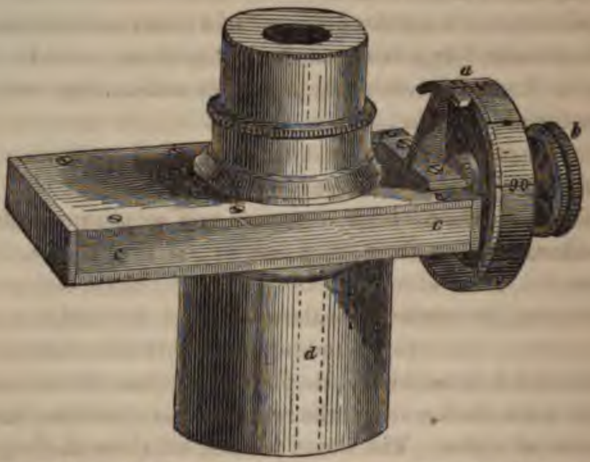
Micrometer, an instrument graduated into $\frac{1}{100}$ths, $\frac{1}{500}$ths, or $\frac{1}{1000}$ths of an inch, for measuring microscopic objects; they are of two kinds called the "stage micrometer," and the "micrometer eye piece."

Micrometer eye-piece, an eye-piece containing a scale which is graduated to certain parts of an inch, say $\frac{1}{500}$ths, for the purpose of measuring objects under examination. Sometimes a cobweb micrometer is employed, but this is not much better than the preceding, and by far more costly. *See figs.* 12, 13.

In addition to the Micrometers referred to on page 30, it may be proper to name one termed the "*Cobweb Micrometer.*" It is a negative eye-piece, having two threads of spider's web running across the field; one thread is stationary, the other can be separated by means of a screw, the milled head of which is represented at *b*, fig. 90; the threads of this screw are about one fiftieth of an inch apart, and the distance to which the cobweb threads are at any time separated by it, may be

known by the divisions marked on the head of the screw at *a*, which is divided into one hundred parts, each part representing the five thousandth of an inch. One complete revolution

Fig. 99.



of the graduated head of the screw separates the cobweb threads one fiftieth of an inch apart. The part of this eye-piece which is passed into the upper end of the Compound body of the Microscope is indicated at *d*.

Micropyle, a small aperture left at the apex of a nucleus or commencing ovule, which is occasioned by its coats not wholly closing around it, and into which the pollen tubes penetrate. The mouth of the foramen of an ovulum. *Lindley.*

Microtome, a cutting instrument used in microscopic dissections, with two blades, somewhat resembling a miniature pair of "sheep-shears."

Midrib, a large vein, termed percurrent when continuing the whole length of a frond; a continuation of the petiole into the leaf. *Lindley.*

Mitriform, mitre-shaped.

Mollusca, soft, fleshy, unjointed animals, having a shell partly or entirely covering them, and, usually, without any development of organs of sense. Snails, oysters, cuttle fish, shell animals, etc., belong to this division of animals.

Monads, the simplest genus of microscopic animalcules.

Moniliform, composed of a series of knots, resembling a string of beads.

Morpho-Menelaus, an exotic butterfly; the scales of this insect are of a rich-blue tint, and afford a good test object for medium powers, showing longitudinal striæ, which under a high power are separated into a sort of beaded subdivision.

Movable stage, a stage for holding glass slides and objects, which is so arranged by screws, racks and pinions, or lever, that it may be moved horizontally in all directions, but never to or from the object glass.

Mucronate, ending in a mucro, or sharp rigid point.

Multifid, much divided, or cleft.

Multilocular, *Multiseptate*, having many cells or chambers.

Muricated, rough with sharp points or prickles.

Muslin Net, a metallic ring three or four inches in diameter, with a fine piece of cambric muslin attached to it in such a manner as to form a small bag; and which apparatus is fastened to the end of a rod or walking cane for the purpose of collecting the larger animalcules, desmidiæ and diatoms, free from any great amount of water. The water passing off through the pores of the muslin.

Mycelium, the vegetative or nutritive apparatus of Fungi, composed of delicate, jointed, interlacing filaments or branching cells; the plant usually rests on it. pl. *mycelia*.

Myriapoda, an order of insects having many feet or legs, as centipedes. *Bell.*

N.

Nacreous, having an iridescent luster like the mother of pearl. *Brande.*

Nascent, the commencing act of growth or existence; beginning to be evolved or produced.

Naviculaceæ, *Naviculæ*, boat shaped-diatoms, some of which are very beautiful, and are used as test objects, requiring excellent objectives of high power and large angle of aperture to exhibit their markings; as the Navicula Hippocampus. Many of them are now called *Pleurosigma.*

Naviculate, naviculoid, boat-shaped.

Needle holders, handles for the purpose of holding needles in microscopic dissections and examinations. A cedar or pine stick properly whittled, with a needle fastened in one end, will answer every purpose, and is less clumsy.

Nemathecia, a kind of fructification in some sea-weeds, resembling

warts, and concealed under leafy processes; the nemathecium when magnified resembles moniliform filaments.

Nitescent, shining, bright, lustrous.

Nitzschoid, like the Nitzschia, having long flat frustules, and linear keeled valves.

Nobert's Test, a small glass slide on which M. Nobert rules ten or more series of lines in a space not exceeding the fiftieth of an inch; each one of the series forms a band, in which the lines are divided into equal distances, and each band has its divisions regularly diminished, so as to present a succession of progressingly increasing difficult tests; some of the series can be resolved by a $\frac{1}{4}$, $\frac{1}{8}$, or $\frac{1}{12}$ inch objective, while others have not yet been resolved. The lines vary in distance from the $\frac{1}{10.000}$th of an inch as the widest, to the $\frac{1}{80.000}$th, or even still closer.

Nodose, having knobs or swellings.

Nodule, a little knob-like eminence; a rounded irregular lump or mass.

Notommata, a genus of Rotatoria, of the family Hydatinæa; they are well adapted for the study of the internal structure.

Nucleus, (pl. *nuclei*) the central part of a body; the part around which matter or bodies collect or form. *Woodward.* The central spot of a cell; iodine brings it into view turning it brownish-yellow, and its membrane pale-yellow; if a drop of the iodized solution of chloride of zinc be afterwards added, the cell membrane becomes of a beautiful blue color, whilst the nucleus and the granular protoplasm that surrounds it, retain their brownish-yellow tint.

Nucleolus is a secondary nucleus formed within the primary one. (pl. *nucleoli.*)

Nympha, the immovable state of an insect during its metamorphoses previous to its becoming a perfect insect. Also known by the names, aurelia, pupa, chrysalis.

O.

Obcordate, heart-shaped, the notched end at the apex.

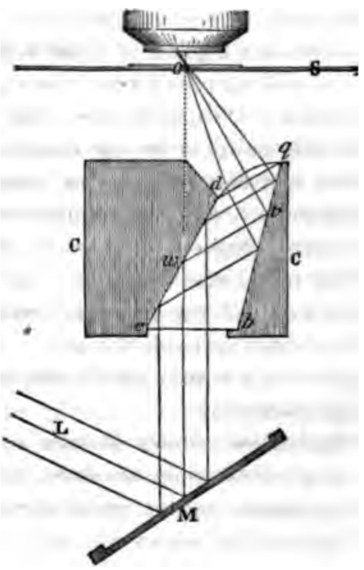
Objective, *Object glass*, the lens or series of lens in an achromatic microscope which is placed immediately above the object when on the stage. Their powers vary from 2 inches to $\frac{1}{16}$th of an inch, and to act with precision it is necessary that their spherical and chromatic aberrations be corrected. Object glasses

should be carefully protected from the vapors of the concentrated acids, fluoric acid, sulphureted hydrogen, hydro-sulphuret of ammonia, chlorine, etc., and from the action of all substances of a corrosive nature which may injure the under side of the object glass, or the brass-frame in which it is enclosed. Alcohol and ether should never be used for cleaning the object glasses, or at least only with great care, since these fluids readily penetrate between the fastening of the lenses, and may reach the cement which unites the crown glass to the flint glass; in which case, the lens can only be made fit for use again by a manufacturer of objectives.

Oblique, running sideways.

Oblique Illumination, is when an object is illuminated by a side light, so that the light does not fall upon every part of it; it is a very efficient way of bringing out marks and structures which cannot be seen otherwise. Oblique light may be thrown upon an object by means of the ordinary mirror attached to the microscope, by means of a condensing apparatus made for the purpose, or by means of the bull's eye condensing lenses. Nachet's prism for this purpose is a very good one, (*fig.* 100). It is placed under the stage, and may be moved around so as to give light from any direction. A beam of light L, falling upon the plane mirror M, is reflected upon the prism *b c d q;* entering the prism, it undergoes total reflection in the range *w v*, and is then thrown in the direction *v* O, being converged to a focus upon the point O where the object lies on the stage of the microscope. C C, is the piece of tube in which the prism is set.

Fig. 100.



Oblong, three or four times longer than broad. *Harris.*

Obovate, the ovate leaf reversed, having the narrow end attached to the stem.

Obsolete, partially indistinct, not well defined; when wearing away.

Obtuse, blunt or dull.

Ocelli, (*s. Ocellus.*) rudimentary eyes. Stemmata.

Octospores, a cluster of eight germ cells formed by duplicative subdivison of the sporangia or parent cell, and when fecundated by the antherozoids they rapidly begin to form themselves into new plants.

Œsophagus, the gullet or tube through which nourishment, etc., pass from the mouth to the stomach.

Olivaceous, a dusky green inclining to brown.

Oospores, ovule-spores; producing-zoospores. See *Trichosporanges*.

Opaque, not transparent; not penetrable by the rays of light.

Opercula, (*s. operculum*,) lids closing the apices of the spore-capsules of mosses, and which fall off when the spores are matured, in order to give them a free egress.

Ordinate, when spots, etc., are placed in regular rows.

Orifice, an opening; the mouth.

Orthotropous, *Orthotropal*, see *Atropous*.

Ostiole, a pore or mouth; a small aperture in the cortical layer or outer bark of lichens, through which air and light are admitted to the apothecia.

Oval, or *Elliptical*, equally rounded at both ends, having the longitudinal twice the length of the transverse diameter.

Ovary, the part in which *ova* or eggs are produced. The ova of animalcules are generally enclosed in a delicate transparent membrane, which becomes very obvious by the action of acetic acid, which contracts the substance of the ovary and throws the membrane into sharp folds, rendering the germinal vesicles and spots of the future ova more evident.

Ovate, shaped like the longitudinal section of an egg, with the attached end the broadest.

Oviparous, produced by eggs hatched after ejection from the body.

Ovipositor, the organ which serves insects to pierce wood, bodies of animals, etc., in order to deposit their eggs in the opening thus made.

Ovisac, the bag or cavity containing the *ovum* or egg, when in the ovary.

Ovoid, approaching to the shape of an egg.

Ovoviviparous, when the eggs are hatched in the body of the animal and the production excluded alive.

P.

Palmated, shaped like the hand with the fingers extended.

Palpi, feelers or small jointed and movable appendages placed on each side of the mouth of insects; those attached to the maxillæ are called "maxillary palpi," and those to the lips "labial palpi."

Panduriform, fiddle-shaped.

Panicled, in a loose spike.

Papillate, with papilla, or nipple-like eminences.

Parabolic Illuminator, a paraboloid of glass intended to produce a black ground illumination; a very excellent contrivance.

Paranemata, branched hairs on which are inserted numerous transparent, ovoid, antheridial sacs, of the Fucoid plants.

Paraphyses, abortive filaments or antheridia; minute, straight, more or less delicate-jointed, elongated cells or hair-like filaments, which occur in small numbers around and between the antheridia and archegonia of Mosses and Lichens. The same term is also applied to simple tubular, more or less clavate cells, occurring in large numbers among the spore sacs (*asci* and *thecæ*) of some Fungi and the Lichens. *Mic. Dict.*

Paraptera, see *Pterygodes*.

Parasite, *Parasitic*, one plant or animal growing upon another.

Parenchyma, spongy matter; the pith or substance; cellular tissue. *Parenchyma proper*, where the cells have polygonal forms.

Parietes, walls.

Patagia, or tippets, a pair of oval plates, covered with hairs, on the upper side of the proto-thorax, in the Lepidoptera.

Patent, spreading, expanding.

Pectinate, with divisions like the teeth of a comb. Antennæ with longitudinal, comb-like series of processes resembl

Pectinato-pinnate, partaking of both the pinnate characters.

Pectus, the breast.

Pedicel, *Peduncle*, the stalk of the fruit.

Pedicellariæ, appendages or arms over the cutaneous surface of sea slugs, sea-hedge-hogs, star-fishes, etc.; they usually consist of two long forceps-like or two broad valvular arms, with which they grasp bodies. They are probably analogous organs with the bird's head processes, *avicularia*, of the polypes.

Pelagic, belonging to the deep sea.

Pendulous, drooping to a greater degree than "cernuous."

Penetrating power, that power in a microscope which is the measure of the brightness of an object, or of the angle subtended by the eye at the object. See *Visual power*.

Pentangular, having five angles or corners. *Grew*.

Perfoliate, a leaf whose base entirely surrounds the stem transversely. *Martyn*. Antennæ having the knob divided horizontally.

Perforate, having holes as if bored with a sharp instrument.

Pericarp, the vessel of a plant in which the seed is contained.

Perichætial, surrounding the pistillidia or pedicel.

Perichætium, a sort of calyx, or narrow and pointed leaflets which surround the base of the seta, or stalk of the sporangium or seed-vessel of certain cryptogams.

Periderm, the leathery cork, flat, tabular layers or cells in the bark of birch, abies, beech, cherry, alder, and generally in all smooth stemmed trees.

Peridium, a leathery or membranous, simple or double sac, enclosing a pulverulent or gelatinous mass, and which bursts in various ways at maturity; it is borne on the mycelium of Gasteromycetous Fungi, as puff-balls. pl. *Peridia*.

Peridioles, *Peridiola*, simple vesicular sporanges filled with minute spores, and borne on the byssoid or flocculent mycelium of some microscopic Fungi. Membranous sacs.

Perigastric cavity, the cavity around the stomach.

Perigone, the external envelop of antheridia and pistillidia.

Perigonial, leaves surrounding the anthers or antheridia.

Periphery, the circumference of a curvilinear figure, (*Brande*); an envelope.

Perisperm, the exterior albumen or tissue of the nucleus, when it exists in the fruit of plants.

Perispore, external membranous sacs or sporanges, enclosing spores; the external envelope of a tetraspore or sphœrospore.

Peristome, the toothed fringe around the mouth of the spore-capsule after the operculum has fallen off, and which seems to aid in the dispersion of spores.

Perithecium, pl. *Perithecia*, the case or special envelope, mostly of different structure from the rest of the thallus or the receptacle, enclosing the "nucleus," or reproductive organs of certain Lichens and Fungi.

Petaloid, having the form of petals.

Phenogamous, *Phanerogamous*, flowering plants.

Phosphorescent, shining in the dark, like the glow-worm.

Phytoidal, like a plant.

Phyton, a bud, or new plant.

Phytozoon, pl. *Phytozoa*, plant-animals, analogous to the *spermatozoa*, in animals; they are found in the antheridia, or reproductive cells of Mosses, Algæ, etc.

Pileus, a fleshy cap or disc on fungi, as on the mushroom.

Piliferous, furnished with hairs at the extremity.

Pinnæ, *s. pinna*, winged leaflets, or portions of the frond or leaf.

Pinnated, winged; having winged leaflets.

Pinnatifid, feather-cleft, cut transversly into oblong segments. *Martyn.*

Pinnules, branchlets of pinnate leaves or fronds. *Martyn.*

Pipette, see Dipping tubes.

Pistillidia, or *Nucules*, bodies in mosses, of a linear or oblong form, which contain the germinating properties, and which ultimately form the future capsules, (*s. pistillidium.*) See Archegonia.

Placenta, a pillar often formed by the thickening of the partitions of the pericarp; the part to which the spores are attached.

Plain Stage, a simple stage to hold objects under examination with a microscope, having no mechanism for moving them about, which is usually done by the fingers of the operator.

Plane, level flat.

Plano-convex, a lens, plane on one surface, and convex on the other.

Plasma, the generative or formative material of animal tissues; a semi-fluid, viscid substance, of a similar composition with the "protoplasm" of plants, but destitute of chlorophyll-granules, and at the expense of which nutrition occurs, and is continued.

Pleurocarpi, mosses in which the fruit is lateral.

Plicate, plaited; in fan-like plaits.

Plumose, feathery, or appearing like feathers.

Plumule, a small feather; a minute stem. The bud or ascending portion of the embryo of plants, which ultimately forms the stem, opposite to the axis.

Podetium, a stalk-like process or thallus of lichens, containing the apothecia or fructification at its summit.

Podura Plumbea, spring-tail, a small wingless insect of a leaden appearance, found in damp wine cellars, leaping about in the saw-dust like a flea. It is also found in shady damp places, as under stones, flower-pots, etc. The scales on its body are used as test objects.

Polarization of Light, is "that faculty which certain bodies possess of so altering a beam of ordinary white light incident upon them, that it is no longer capable of being transmitted by certain other transparent substances, at certain angles, or in certain positions; so that under the requisite conditions these crystalline diaphanous bodies become as if opaque to this polarized light. There are several means of polarizing a beam of ordinary light, as—by *reflection*, from the surfaces of glass, china, water, resin, and other polished substances not possessing metallic properties; by *transmission*, *a* by double refraction, as by carbonate of lime; *b* by absorption, as by tourmaline; *c* by dispersion, as by agate, etc.

"The doubly refractive power of carbonate of lime has been generally made use of for the study of these phenomena, and Nichol's prism, (a rhomb of carbonate of lime cut in a peculiar manner) has the power of splitting the incident ray into two equal portions, one of which it transmits polarized in one plane, while it obstructs the other, or that polarized in a plane at right angles to the transmitted ray. Upon revolving this prism on its axis, that beam which was before transmitted becomes obstructed in its turn, and thrown out of the crystal by reflection; whilst that before obstructed is now transmitted.

"The phenomena exhibited by absorption are almost always studied by the action of the tourmaline on a beam of ordinary light. This mineral, when cut into plates parallel to the axis of the crystal, has the remarkable property of dividing the ray of light into two parts, one of which it transmits readily, but

slightly altered in color; the other it wholly absorbs, at least, it disappears, and is not to be found by the experimenter, until the plate is revolved 90°, when the ray becomes transmitted, and the former one now disappears.

Fig. 101.

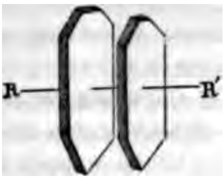
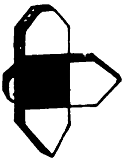


Fig. 102.



R R' in fig. 101 represents two plates of tourmaline, held in the same position, one before the other; the beam of light, polarized by the one, readily passes through the second plate. But on rotating one of the plates, the light becomes, more and more obscured, until when placed at right angles with each other, as in fig. 102, the light refuses to pass, and the portions thus crossed present a black opaque ground.

"When two such crystals are superimposed at right angles the whole of the light disappears; the first half is absorbed by the first or "polarizing plate" of tourmaline, technically called the 'polarizer,' and the other half (slightly tinged) passes through polarized; which, as soon as it impinges upon the second crystal of tourmaline, is also absorbed. There is now no light transmitted, the field of view is as black as midnight, or as opaque as the darkest bottle-glass.

"When the tourmalines are in this position, if a thin film of selenite or sulphate of lime be introduced between them at a certain angle of rotation, the light will now pass the second tourmaline and be transmitted to the eye—a certain thickness is required in this experiment as well as a certain angle of rotation. If the crystal be less than the 0.00046 of an inch in thickness the light is not transmitted; if it be above the 0.01818 of an inch the light passes, but perfectly white; if of any intermediate thickness, from 0.00124 of an inch to the 0.01818 of an inch, the most splendid colored lights will be exhibited; either blue, yellow, red, or in various shades of these primary colors, or in various mixtures of them; so that we may have blue, orange, yellow, green, indigo, or violet, according to the thickness, the law of this succession of change is known by philosophers to depend upon the thickness of the plate of crystal, and the changes pass through a certain order of colors; namely, those commonly known as Newton's rings, so that a

color of a certain order will always indicate a certain thickness of selenite plate." *W. B. Herapath, M. D.*

"Polarized light is of much service to the microscopist, enabling him to discover the existence, in many tissues, of differences of density which would be inappreciable under ordinary illumination. Unequal density being accompanied by the property of double refraction, these tissues when examined with polarized light exhibit the phenomena of colored polarization. It sometimes happens that the doubly-refracting property of the tissue is not sufficiently powerful to produce color, and in such cases it is necessary to place a thin plate of selenite under the object. For convenience in use, the plate is sometimes cemented to a piece of plate glass and covered by a piece of thin glass joined to it by Canada balsam, and the apparatus is called a Selenite-stage.

"The polarizing apparatus produces beautiful appearances in all irregularly laminated cells. All cells in which the thickening substance is laminated exhibit the cross which is seen in grains of starch; the pits in the wood of Coniferæ and the ducts of the albumen of Phytelephas, or Phœnix dactylifera, exhibit, when seen from above, the same cross. All bast cells, when viewed separately, or in longitudinal section, show beautiful colors. Wood-cells, such as those in the vascular bundle of Caryota urens, are also very beautiful." *Currey, in Schaht on the Microscope.*

The naked eye cannot distinguish polarized from common light. The properties of each are given as follows, by Pereira, in his "Lectures on Polarized Light," a very instructive little volume:—

A RAY OF COMMON LIGHT.	A RAY OF POLARIZED LIGHT.
1. Is capable of reflection at oblique angles of incidence in every position of the reflector.	1. Is capable of reflection at oblique angles of incidence in certain positions only of the reflector.
2. Penetrates a plate of tourmaline (cut parallel to the axis of the crystal) in every position of the plate.	2. Penetrates a plate of tourmaline (cut parallel to the axis of the crystal) in certain positions of the plate, but in others is wholly intercepted.
3. Penetrates a bundle of	3. Penetrates a bundle of par-

ized light should be immersed in turpentine or Canada balsam, to render them as transparent as possible.

Polycistina, rhizopods with siliceous coverings perforated with numerous minute apertures.

Polygastrica, infusoria with many stomachs ; not used at present.

Polymorphous, having many forms. *Bigelow*.

Polyommatus Argiolus, azure-blue butterfly, the scales of which are used as test objects, as also those of *P. Argus*, whose scales are shaped like a battledore.

Polyparium, See *Polypidum*.

Polypi, zoophytes.

Polypidum; the house, or external, or internal axial skeleton of the polypes ; the horny, leathery, or calcareous sheath investing their bodies.

Polypiferous, bearing polypes.

Polythalamous, many chambered ; applied to cephalopods having multilocular cells. *Pen. Cyc.*

Polyzoa, animals enclosed either in a horny or calcareous sheath, and are distinguished from Hydraform polypes by the cilia on their tentacles. They are a species of zoophytes, strongly resembling the true mollusks, in their structure. They propagate by spontaneous division ; by the formation of gemmæ or buds ; and by the formation of ova.

Polyzoary, the composite structure formed by a cluster or colony of individual cells or sheaths of Polyzoa.

Pontia Brassicæ, the large cabbage butterfly ; the scales on the under side of the wings of the males, are used as test objects.

Porifera, Sponges ; Rhizopods in which the skeleton is usually composed of a net-work of horny fibers, strengthened by calcareous or siliceous spicules ; sometimes they are furnished with cilia.

Posterior, placed after, behind.

Prehensile, catching ; holding ; formed to grasp or seize.

Preservative fluids or *mixtures* are those compounds used in the mounting of microscopic objects which will preserve them for the longest possible time and with the least alteration. They vary according to the character of the objects, and principally consist of the following :—

1. *Canada Balsam*, is used as a preservative material in all cases where it is of importance to heighten the transparency

of the object, as in mounting specimens of pollen grains, sections of hard fruit, envelopes, corals, shells, and injected preparations which suffer no change by previous drying, diatomaceæ, chalk with foraminifera, hairs, insects, sections of wood, fossil infusoria, scales of butterflies, etc. That balsam should be selected which is perfectly transparent, almost colorless, and very viscid. It should be kept in a wide mouthed bottle, covered by a ground glass cap; an ordinary glass alcoholic lamp with a wide mouth and cap will answer, with a glass rod in it drawn at one end to a blunt point, its upper end projecting into the cap. It becomes thicker by keeping, but may be rendered thinner by mixing it with oil of turpentine and digestion at a gentle heat; if too thin, it should be exposed to a gentle heat in a bottle covered with paper to exclude dust. Canada Balsam is sometimes diluted with chloroform, which is placed around the object, when the chloroform evaporating rapidly, leaves the Canada balsam unchanged. This is very useful where it is desirable to avoid heat on account of coagulating albuminous fluids, etc. The mixture should only be made at the time it is used; keeping it imparts an opacity to it. *Oily or fatty subjects may be mounted thus, after having removed the oil by soaking them for a sufficient length of time in turpentine.*

Some recent and *moist structures, animal and vegetable, admit of being mounted in Canada balsam, without being previously dried, thereby preventing any distortion of them. The plan is to take the specimen from the water or other liquid in which it has been prepared, let it drain a little, and then immerse it in alcohol; after a short time (varying from one or two to ten or fifteen minutes, according to the size and thickness of the specimen), remove it from the alcohol, and, after draining, place it in pure methylic alcohol or pyroxilic spirit. After allowing it to remain a few minutes in this liquid, it may be removed, drained, and immersed in spirits of turpentine, on being taken from which, after a few minutes, it may be placed in balsam, and be proceeded with in the usual manner; the balsam ought to be sufficiently fluid not to need the employment of heat. Injected specimens, sections of roots, woods, barks, preparations of nerves, etc., may be well preserved and displayed in this manner. H. J. Burrowle.*

2. *Distilled Water* will be found an excellent preservative

for many of the Diatomaceæ and Desmidiaceæ. If the cell in which they are mounted can be made perfectly tight, so that the action of the air upon them can be prevented, there will be less change in their color and structure than with any other preservative fluid. As, however, confervæ are apt to appear when water only is used, they may be prevented by adding as much camphor to the water as it will take up, or, a drop or two of creosote. Or, a grain, each, of alum and bay-salt may be dissolved in a fluid ounce of distilled water, and used as the preservative fluid. One part of alcohol to nine parts of distilled water forms an excellent preservative for those microscopic plants, where it is not required to preserve their color.

3. *Spirit and Water* in the proportion of five parts rectified alcohol to three of water is sometimes used for preserving animal structures, organs, injections, etc. Delicate preparations may be kept in a mixture of one part alcohol to five of water. Dilute spirit should never be used as a preservative when it can be avoided. In using this fluid, the covers of cells may be cemented down with gold size, or asphaltum.

4. *Goadby's Solutions.** These are of three kinds, and are mostly adapted for mounting large animal structures; if used otherwise, the corrosive sublimate should be omitted, and it should also be left out when ova are to be preserved, or when it is desired to maintain the transparency of certain tissues. They are as follows:

A 1. Take of bay salt, (coarse sea salt) four ounces, alum two ounces, corrosive sublimate two grains, water boiling one (imperial) quart. This is too strong for most purposes, and is only to be employed where great astringency is required to give form and support to delicate structures.

A 2. Bay salt four ounces, alum two ounces, corrosive sublimate four grains, boiling water two (imperial) quarts. This is recommended for general use, and is best adapted for permanent preparations. When carbonate of lime exists in the preparation, as in the Mollusca, it decomposes the alum, a sulphate of

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* Professor H. Goadby has kindly furnished me with the formulæ for his preservative fluids to place in the present volume. The imperial quart is twenty ounces by weight, or thirty-three fluidounces, two fluidrachms, and thirty-six minims, Apothecaries or Wine Measure.

lime is precipitated and the specimen is injured; for such use the following:

A 3. or B fluid of specific gravity 1.100; take of bay-salt eight ounces, corrosive sublimate two grains, water one (imperial) quart. Marine animals require a stronger liquid of this kind made by adding about two ounces more salt to the mixture. For its softening qualities, and to preserve color, he sometimes adds from twenty to sixty grains of arsenic to an (imperial) pint of the last, No. 3 fluid.—first boiling the arsenic in water over a spirit lamp till the whole be dissolved, and then adding it to the preservative fluid in proper proportion.

Neither of the first three fluids should be employed of full strength at first; the animal must undergo previous maceration in clean water, to which after a time, the preserving fluid may be added from day to day, mixing it intimately with the water, and continuing its use until the animal rises to the surface, being completely saturated with the preservative mixture.

5. *Salt* (*chloride of sodium*) *and water;* a tolerably concentrated solution saturated with camphor to prevent the growth of fungi, is said to be an excellent preservative for many animal and vegetable tissues, and especially for the delicate structures and nerve-cells of the internal ear. Salt five grains to an ounce of water, with the addition of acetic acid, and a few drops of camphor or creosote, will answer to preserve the color of most minute vegetable tissues, as the smaller fungi. Spermatozoa may be preserved in a very dilute solution of salt.

6. *Chloride of Calcium*, (muriate of lime). This is made by adding from two to ten parts of water to one of the dried chloride, according to the delicacy of the specimen; the solution should be perfectly free from traces of iron, and may be used for sections of bone, teeth, hairs, feathers, fish-scales, whalebone, cheesemites, itch-insect, small fresh water crustacea, vegetable preparations whose cell walls or vessels have undergone a partial incrustation, for displaying the cells or loricæ of the siliceous bacillariæ and diatomaceæ. The cells containing it should be filled having no access to air, otherwise vegetable growths will occur in it. It also has the disadvantage of altering the disposition of cell contents, and of not preserving colors, also of oxidizing metallic instruments. A little camphor may be advar added to it. This solution should not be

used for preserving starch grains, as they swell and become deformed.

7. *Thwaite's Liquid*, as improved by Dr. Beale is made by mixing three drachms of creosote with six ounces of wood naphtha, adding to it, in a mortar, as much prepared chalk as may be sufficient to form a smooth thick paste; distilled water must now be gradually added, in small quantities at a time, to the extent of sixty-four ounces, and the mixture be well rubbed together. Add two or three small lumps of camphor, and allow the mixture to stand in a lightly covered vessel, for two or three weeks, with occasional stirring; after which it should be filtered, and kept in well stopped bottles. Used in mounting animal substances, desmidiæ, etc., exerting little or no action on the endochrome. The original formula is sixteen ounces of water, one of alcohol, creosote sufficient to saturate the spirit, chalk as much as may be necessary. Mix the alcohol and creosote, stir in the chalk with the aid of a pestle and mortar, and add the water gradually. Next add saturated camphor water, an equal quantity, let it stand a few days, and filter. Quekett recommends one part of naphtha to seven or eight of water as a good preservative fluid.

8. *Ralf's Liquid*, for the preservation of delicate specimens of Algæ, is prepared by adding one grain, each, of bay salt and alum, to one ounce of distilled water.

9 *Acetate of Alumina*, (Gannall's solution.) One part of the acetate of alumina to four of distilled water, preserves very delicate colors of vegetables, etc.; when injected into the blood vessels prevents decomposition of the animal tissues, and is used for their preservation on a large scale. It is destructive to bone.

10. *Creosote Water*, is prepared by filtering a saturated solution of creosote in one part of rectified spirit, after mixing it with twenty parts of water. Used for preparing specimens of muscle, cellular tissue, tendon, cartilage, ligaments, fibers of the crystalline lens, and sections of bones and teeth which have been treated with acid. It is not adapted for blood corpuscles, ultimate nerve tubes, and adipose tissue. It acquires eventually a brownish-yellow tint; and the creosote is apt to leave the water and adhere to the sides of the vessels containing it.

11. *Solution of Arsenious Acid.* An excess of arsenious

acid is boiled with water, the solution then filtered, and two parts of water added. This is a very good preservative of animal tissues, imparting little or no tinge, and keeping them unaltered.

12. *Solution of Corrosive Sublimate* for preserving blood corpuscles, nerve, muscular fibre, etc. The solution must vary according to the nature of the object to be preserved; being one part of corrosive sublimate dissolved in from 200 to 500 parts of water. It is also useful for keeping the elementary parts of the brain, spinal cord, and retina, all delicate organs in which it is desired to retain the starch globules and chlorophyll unaltered, fresh water algæ, confervæ, diatomaceæ, rotiferous animalcules, etc.,—1 part of salt to 500 of water.

13. *Solution of Carbonate of Potassa*, for preserving primitive nerve tubes. One part of the salt dissolved in from 200 to 500 parts of distilled water. Also useful to display the respiratory apparatus of insects with the ramifications of the air-tubes.

14. *Solution of Arsenite of Potassa;* one part of the salt dissolved in 160 parts of distilled water. To preserve the primitive nerve tubes.

14. *Glycerine.* Equal parts of glycerine and camphor water, or, better, one part of glycerine to two of camphor water; if it be used pure, it will act on marine glue, and endochrome, if too dilute, confervoid growths will occur. Used for mounting infusoria, and delicate animal and vegetable tissues, preserving their colors. Salt, corrosive sublimate, alcohol, or creosote may be added to the glycerine, if desired. Air-bubbles form in glycerine, which are of difficult removal.

15. *Deane's Gelatine*, for the larger forms of confervæ, and dry or moist animal or vegetable structures. Take of best gelatine one ounce, soak it until soft, and then add honey which has been previously raised to the boiling point, five ounces; then boil the mixture and when it has cooled somewhat, add six drops of creosote dissolved in half an ounce of rectified alcohol; while still hot filter through fine flannel. When required for use, the bottle containing the mixture must be slightly warmed, so as to render it fluid, and a drop placed on the preparation upon the glass slide, which should also be warmed slightly. Next, the glass cover, after having been breathed upon, is to be laid on with the usual precautions, and the algæ covered with

a coating of black japan, or Brunswick black. As this fluid becomes solid on cooling, care must be taken that the surface of the drop does not become dry before the application of the glass cover; and the inclusion of air-bubbles must be carefully avoided. The following will be found to answer for mounting insects and some animalcules; dissolve gelatine one ounce in hot water three fluidounces, when dissolved add pure glycerine four fluidounces, camphor water one fluidounce, and mix with care. Used same as the preceding.

16. *Castor Oil* perfectly free from any deposit may be used for the preservation of soluble crystalline salts, as well as for minute fungi and parasitic animals. It presents little difficulty with regard to air bubbles, if the object be dry, but there is sometimes considerable trouble in cementing on the glass cover from the oozing out of the oil; in this case, the best plan is to set the slide, with the thin cover on, aside for a time until the oil hardens, then carefully scrape off the hardened oil around the edges of the cover, and finally apply a layer or two of cement, sufficient to properly fix the glass cover.

17. *Chromic Acid*, may be used to harden and preserve nervous and muscular tissues, as the vitreous humor of the eye, etc., to cut them into thin sections. An aqueous solution of the acid should be prepared as required, on account of its ready decomposition by organic matter; it should be of a pale yellow color. One part of the acid to twenty of water, forms a good preservative for pus, mucus, epithelium, blood corpuscles, spermatozoa, and other delicate structures.

18. *Sulphate of Zinc* in a saturated solution, 14 parts of the salt to 10 of water, preserves the muscles, teguments, cerebral substance, etc., of vertebrata, without injuring the bones or permitting moldiness. It hardens the brain so as to facilitate its dissection, but it dissolves albumen, so as to cloud the liquid. All parts, except the nerves of perfect insects, are well preserved in this fluid.

19. *Balsam Copaiba* will preserve objects of a delicate character, which it is not desired to mount immediately. Objects may be temporarily mounted between two plates of glass, and transmitted by post to distant parts of the country in perfect safety; when thus prepared they may at once be mounted in Canada balsam without further preparation.

20. Boil together, in a Florence flask or porcelain capsule, three grains of arsenious acid, and two fluidounces of distilled water; when cold filter through paper. Take of this arsenical solution one fluidounce, of pure glycerin one fluidounce, of pure gum Arabic one ounce, Troy. Dissolve the gum without heat, which will require about two weeks, occasionally stirring with a glass rod. If the bottle be shaken the *froth* produced introduces air-globules. If necessary, strain through the finest cambric, which has been previously washed by running a considerable quantity of clean, cold water through it. This is used for mounting moist specimens, the arsenious acid being added to prevent the growth of algæ or fungi. It forms a tough elastic preservative medium, with no tendency to crack. Thin sections of recent vegetables, starch corpuscles, mycelium and sporules of fungi, vegetable or animal cells, the thin, delicate membrane of small hydatid cysts, cancer cells, pathological specimens, etc., are better preserved and shown in this medium than in any other. It is to be used in the same way as Canada balsam, placing it upon the object, then covering with thin glass, and removing the superfluity by scraping, and washing with water. *R. J. Farrants.*

21. *Paccini's Fluid* for the preservation of blood-globules, nerves, ganglia, the retina, cancer-cells, and delicate protein-holding tissues. By means of this fluid the red corpuscles are precipitated and hardened, retaining their form so that they may be counted. Take of corrosive sublimate one part; pure chloride of sodium two parts; glycerin at 25° Baume thirteen parts; distilled water one hundred and three parts; mix. Let the mixture stand for two months, then mix it with distilled water in the proportion of one to three parts of water, and filter.

Primordial Utricle, nitrogenous, formative layer; true cell-wall. The primordial utricle consists of a collection of the protoplasm, forming a continuous inner layer of the cell-wall of variable thickness, or as a mass filling the whole cavity, either homogenous or honey-combed more or less by vesicular cavities filled with watery cell-sap. All the other cell-contents are enclosed or imbedded in this primordial utricle, and with it they collectively constitute what is called by some authors the *endochrome*, of the cell. If dilute nitric or sulphuric acid be added, the cell-contents coagulate and collapse, so that the prim-

ordial utricle separates itself from the outer cellulose wall with which it is generally in contact, and shrinks up within its cavity.

Prism, Nicol's. This is a prism, prepared from an elongated rhombohedron of Iceland spar, and named after Mr. Nicol of Edinburg, who first proposed it. The natural prism has its terminal surfaces ground to such an inclination as may be desired; the prism is sawn through obliquely and longitudinally, in such a manner that the sawn surfaces are at right angles with the terminal faces; the sawn surfaces are then polished, and by means of Canada balsam are united in the same position they occupied previous to the division of the prism by the saw. The sides are then blackened and made opaque, the terminal surfaces alone remaining clear for light to pass through.

Fig. 105.

Fig. 105 is a diagram of a longitudinal section of one of these prisms, along its flat side, showing its action upon a ray of ordinary light. The ray enters the prism in the direction *a b*, and is immediately separated into two polarized rays by refraction—the ordinary ray taking the direction *b c*, and the extraordinary ray that of *b d*. Total reflection of the ordinary ray occurs when it reaches the balsam which unites the two obliquely sawn surfaces, as at *c*, and this ray is thrown in a direction above the terminal face of the prism, or so that it does not pass out of this face. The low refractive power of the extraordinary ray prevents the balsam from reflecting it, so that it passes downward and out of the terminal face of the prism, emerging in the same plane *g h*, as that by which the incident ray *a b* entered the prism at its superior extremity.

Prismatic, antennæ, etc. having the shape of a prism, or with three sides.

Proboscidiform, shaped like the trunk of an elephant.

Proboscis, or sheath, containing the trophi or organs of the mouth in some insects, by means of which they suck blood or juice from organized bodies. Vibratile cilia.

Process, any projecting part, or eminence. *Coxæ.*

Produced, lengthened out.

Proliferous, fertile, productive; when a second frond springs from the first.

Promuscis, or *Rostrum*, the part forming the mouth in many sucking insects.

Pronotum, the posterior or dorsal half of the protothorax.

Prosenchyma, cellular tissue, usually forming the mass of wood and various fibrous structures of vegetables, where the cells are attenuated to a point at each end, the cells, "fibers," being intercalated, and applied side to side. *Mic. Dict.*.

Prosternum, the anterior or sternal half of the protothorax.

Protein, a name given by Mulder to certain substances, as Albumen, Fibrin, and Casein, which are mere modifications of one compound, and may be regarded as the starting point and commencement of all the organic tissues. It may be obtained pure by washing either of the above substances successively with water, alcohol, and ether, to remove extractive matter, fat, and soluble salts, then treat it with dilute hydrochloric acid to remove the phosphate of lime and other insoluble salts present; finally dissolve it in a moderately strong solution of caustic potash, keep the solution for some time at a temperature of 120°, so that any sulphur and phosphorus present may form phosphate of potash and sulphuret of potassium. Filter the solution, and add acetic acid in slight excess, which precipitates the protein. Collect it on a filter and carefully wash it with distilled water till every trace of acetate of potash is removed. Protein forms grayish white gelatinous flocks, which are hard and yellow when dried, giving an amber colored powder. It is odorless, tasteless, insoluble in alcohol, ether, or water, absorbs moisture and swells up, and combines with acids and bases. Ferrocyanuret of potassium, tannic acid, and anhydrous alcohol, precipitate it from any of its acid solutions.

Prothallium, the cellular structure first produced in the germination of the spores of the higher flowerless plants. In the mosses this is a Confervoid expansion upon which buds are formed from which arise the leafy stems. In the Ferns it is a flattened leaf-like expansion, upon which are subsequently produced the antheridia and germ organs called ovules, and from the latter the young plant springs. In the Lycopodiaceæ and Marsileaceæ, the prothallium is produced within the coats of the ovule-spore. *Mic. Dict.*

Protophytes, the simplest plants, the primitive or elementary forms of vegetation.

Protoplasma, formative tissue of vegetables; the viscid, granular, nitrogenous organizable fluid in plants or cells, at the expense of which the nutritive act seems to take place; it contains albuminous matter combined with dextrine or starch gum. In vegetable cells, it forms part of the endochrome, or cell contents. Protoplasm, unlike cellulose, is always colored yellow-brown by the treatment with sulphuric acid and iodine.

Protothorax, or *ante-pectus*, the first or anterior ring or segment of the thorax in insects.

Protozoa (*s. Protozoon*,) minute and simple forms of animals, being constituted of cells either isolated or aggregated, which are destitute of both the "cellulose wall," and chlorophyll granules of plant cells.

Proventriculus, gizzard or muscular stomach.

Proximal, contiguous; bordering upon; before the mouth.

Pruinose, a surface covered with mealy grains, like frost.

Pseudo-nodule, an imperfect nodule.

Pseudopodia, contractile tentacular filaments or false legs made by the prolongation of the sarcode among Rhizopods, as in *Actinophyris sol.*

Pseudoscopic, a defective appearance of an object in which the projecting parts of it appear to be excavations, and its depressions to be prominences.

Pteropoda, a division of the mollusca, characterized by possessing no organ to fasten themselves to other bodies, or to crawl by, but who are constantly swimming by means of fleshy, wing shaped fins, or membranes, placed one on each side of the mouth.

Pterygodes, *paraptera*, or *tegulæ*, large triangular scales attached to the upper part of the base of the anterior wings, at the sides of the mesothorax, and often covered with hairs or scales of a different color from those on the other part of the thorax. In Lepidoptera. *Mic. Dict.*

Pullulate, to bud; to commence germination; shoot forth.

Pulvilli, several insects, and particularly those of the fly species, have two cushions or membranous expansions to each foot, which are covered with delicate hairs, each one having a minute

disc on its end, which serve as suckers, aiding the insect to walk over polished surfaces when in an inverted position.

Pulvinate, shaped like a cushion.

Puncta, points or dots.

Punctated, covered with points or dots.

Pupa, *chrysalis*, *nympha*, or *aurelia*, the second state of existence among some insects, previous to their attaining a state of perfection; some pupa present a gilded appearance.

Purpura lapillus, rock-whelk, a Gasteropod of considerable interest to the microscopist.

Pycnidia, conceptacles or sporanges in the vine-fungus and Lichens, in which asci, or stylospores are developed. The perithecia of the secondary fruit of Lichens.

Pygidium; the abdomen of the female flea has nine distinct rings, the first seven consisting of horny arches with membranous margins. The eighth arch has no membranous margin, but is strengthened by a horny band furnished with fine hairs. The ninth and last segment, is called the *pygidium*; it is somewhat reniform or two-lobed, folded on the dorsum, and exhibits twenty-five to twenty-eight stiff and longish bristles, each of which is surrounded at its base by a disc-like areola, ornamented with a ring of rectangular or somewhat cuneate rays. Minute spines exist between the areolæ.

Pyriform, pear-shaped.

Q.

Quadricornis, four-horned; a crustacean.

Quadriferous, arising from all sides of the stem or branch.

Quadrifid, cleft in four parts.

Quaquaversal, turning in every direction from a center.

Quartine, the fourth membrane or covering of the kernel or embryo in plants.

Quaternate, a leaf having four leaflets, all being on a common petiole.

Quincunx, an arrangement of things in squares, by which one is placed in each corner, and one in the center thus ⁙ —

Quinquefid, cleft five times; divided into five lobes.

Quintine, the sac of the embryo, or the fifth covering from the outer nucleus of a seed. *Lindley.*

R.

Racemous, *Racemose*, growing in clusters, like grapes.

Rachis, the stem of a flower.

Radiated, sending forth rays from a center.

Ramous, branched. *Martyn.*

Ramsden's eye-piece, an eye-piece composed of two plano-convex lenses, the field glass having its convex side upward, and being nearer to the eye-glass than in the Huyghenian eye-piece, to which it is inferior for ordinary microscopic use, as it increases the convexity of the image. It is sometimes called the "positive eye-piece."

Ramuli, twigs or small branches.

Ramulous, branched.

Raphe, a ridge; a kind of adherent funiculis, connecting the hilum of an ovule with the chalaza. *Lindley.*

Raphides, from the Greek *Raphis*—a needle; transparent, needle-like deposits of mineral crystals found in the cells of plants, as crystals of oxalate of lime in the onion and rhubarb plants.

Receptacles, variously shaped bodies containing the seeds of plants.

Recurved, leaf rolled back from the margin.

Red Snow, *Protococcus nivalis*, a plant of microscopic cellular tissue, in the form of filaments, which is found in excessively cold climates, as in the Arctic and Alpine regions; its powers of reproduction are very great, so that large tracts are frequently covered with it, presenting a red appearance, which has given rise to the names "red snow" and "gory dew." It is supposed to be a Palmella.

Reflected Light, in which the light is thrown down upon the object, and the peculiarities of its surface alone observed, as in the examination of opaque objects, or transparent ones on a black-ground.

Refraction, the change in the direction of the rays of light occasioned by their passing through a lens.

Reniform, kidney-shaped.

Resting Spores, still, immovable gonidia, preserved for a length of time by a firm outer covering.

Reticulated, marked like net work.

Retiform, formed like net work.

Retractile, organs are so called which have the quality of being drawn backward.

Revolute, rolled outward and backward.

Rhizopoda, a lower order of animals, whose bodies consist of sarcode without cilia, which they prolong into pseudopodia, whereby they ingest or intromit their food; they may be covered with a carapace or not.

Rhomboidal, like a rhomb, a quadrangular figure with two angles acute and two obtuse.

Rice paper, the pith of an herbaceous stem of a Chinese plant termed *Aralia papyrifera*, cut vertically into a sheet.

Rigid, harsh and stiff.

Rostra, a beak.

Rostrate, (lid of a capsule) pointed in the shape of a bird's beak, or similar object.

Rostrum, a bird's bill; a beak; a snout.

Rotifera, or ***Rotatoria***, animals having ciliated appendages on the fore part of the body, which they seem to move in a rotary manner, (*Brande*), giving the appearance of wheels in motion, and have hence been called "wheel animalcules."

Rotiferous, like a Rotifer; circles of vibratile cilia, single or double.

Rotund, round.

Rufescent, of a reddish color.

Rugose, wrinkled.

Rugulose, finely wrinkled.

S.

Saccate, formed like a sac or bag; provided with a bag.

Sarcode, Blastema, or formative substance of animal cells; a uniform, gelatinous-like contractile substance occurring abundantly in very young animals, worms, zoophytes, &c. It appears to be the vital tissue of some of the lowest order of animals, and bears a resemblance, in many respects, to vegetable protoplasm. It may be known from globules of fat which it somewhat resembles, by being insoluble in liquor potassæ.

Sarcolemma, muscular fiber.

Scaphidia, conceptacles or spherical cavities immersed in the substance of the frond, or in all or special parts of it, among the Fucoideæ, containing spores, antheridia, or both.

Scapus, the stalk or axis of a feather. *Brande*.

Sclerogen, a hard substance deposited around the cells of plants, contributing to their thickness and firmness. When freed from extraneous matters it is chemically allied to cellulose.

Sclerous tissues, hard tissues forming the rudimentary skeletons of animals.

Scolopendra, See *Centipedes*.

Scutate, *Scutiform*, shaped like a shield.

Scutellæ, open apothecia of Lichens, in the form of shields.

Scutellum, a shield.

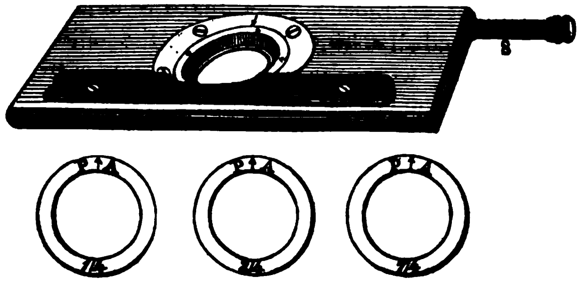
Scyphi, open apothecia, in the form of cups.

Secund, all turned to one side; disposed only on one side.

Segments, parts cut off or separated; divisions of a leaf, frond, frustule, etc.

Selenite, native hydrated crystalline sulphate of lime or gypsum; it is used with the polarizing apparatus of a microscope to exhibit distinct colors of crystals and other substances whose thicknesses are not suited to such exhibition under the polariscope. A film or plate of selenite for this purpose, should be mounted in Canada balsam between two glasses for protection, and is called a "selenite stage." Fig. 106 represents Mr. Darker's Selenite Stage. A brass plate about four inches in

Fig. 106.



length, an inch and a half in width, and one sixth of an inch in thickness, is prepared with a circular orifice in its center, and a piece of brass screwed along one edge to form a ledge on which slides or objects may rest, when the stage is in an inclined position. The central aperture is about an inch in diameter, and has a brass ring fitted into it, which, by the moving of an endless screw S may be revolved in opposite directions, as required. Cells composed of brass rings, with a layer of selenite between two thin glass discs attached to them, are prepared; no one of the several layers of selenite being of the same thickness. These cells, as P A $\frac{1}{4}$, P A $\frac{2}{4}$, P A $\frac{3}{4}$, are made to fit into the movable ring, which having a shoulder on its

lower side, prevents them from falling through. The direction of the positive axis of the selenite is indicated by the arrow between P A. The manner in which these cells are placed upon each other, and their change of position by the movement of the endless screw, causes a most gorgeous display of colors.

Semi, half.

Septum, a band, or partition separating two cells or cavities. (pl. *Septa.*)

Sericeous, soft hairs; silky.

Serpulæ, insects living in calcareous tubes, variously contorted.

Serrate, *Serrated*, toothed or notched, like a saw.

Sessile, attached without a stipe, peduncle, or stem.

Seta, the pedicel or footsalk which supports the capsules of mosses; a hair, or bristle. (pl. *setæ.*) In infusoria setæ do not vibrate like cilia but are used to support the body, and for climbing.

Setaceous, bristly; setaceous antennæ, when they gradually taper toward the extremity.

Sigmoid, like the letter *ſ*.

Simple, undivided; unbranched; not mixed or united.

Sinistral, left handed; left-sided, inclined to the left. *Brown.*

Sinuous, *Sinuated*, when the margin has numerous, shallow, blunt indentations, or curved breaks, as the oak leaf.

Sinus, a depression, groove, or cavity. *Humble.*

Siphuncle, a tube of communication between the chambers, (or cylindrical canals perforating the partitions), in polythalamous shells, as in nautilus, ammonite, etc.

Soluble glass, *Vitrine*, Silicate of Potash, or, of Soda, a thick solution useful for making cells, and cementing on covers. See *Cements*.

Soredia, gonidial cells of Lichens; appearing, on the upper external surface of the thallus, in dust-like groups.

Sori, coalescing or isolated spots, patches, or lengthened bands, or groups of sporanges, on the surface of the fronds of Ferns; they may be naked, or each sorus may be covered with a special membranous structure called *Indusium*. Sori consist each of clusters of sporanges or thecæ.

Spatulate, rounded and broad at the end, and becoming narrow like a spatula; rounded at the apex and tapering at the base.

Spermatia, minute, oval, motionless bodies or spore-like processes

found in the spermogonia of Lichens, probably sperm cells; sometimes they are endowed with molecular movement. They are produced either upon the apices of the cellules which form the walls of the spermogonium, or sometimes laterally from moniliform filaments or other processes which line the cavity of the spermogonium.

Spermatophores, peduncles on the terminal ends of which are the Spermatia.

Spermatozoids, or *antherozoids*, transitory structures produced in the antheridia of the Cryptogamia, regarded as analogous to the spermatozoa of animals, and as the agents of fertilization of the germ cell. They vary much in form, and when discharged from the parent cell they either make their way to a germ cell of a spore, fertilize it and disappear; or if debarred from this, at once perish, without germination. *Mic. Dict.* *See* Antherozoids.

Sperm-cells, antheridia, spermogonia, cells containing the fertilizing bodies of plants.

Spermogonia, small black specks, conceptacles, or peculiar organs found on the shields of Lichens, and on Fungi, supposed to contain spermatia, or fertilizing bodies. *s. Spermogonium.*

Sphacelia, a parasitical fungus.

Spherical aberration, the difference between the focus of the central rays of a lens, and that of its marginal rays, by which an image is rendered more or less indistinct; in achromatic lenses or microscopes this as well as chromatic aberration, is or should be corrected.

Spinous, armed with spines.

Spinulate, having one end knobbed or globular, like the head of a pin, and the other pointed.

Spinnerets, the articulated tubes with which spiders, etc., spin their tubes.

Spiracles, breathing apparatus of insects.

Spongioles, that portion of the extremity of radicals or rootlets, by which they absorb their nourishment.

Sporanges, or spore-sacs, have an outer membrane, perispore; and an inner one, epispore; both are distinguishable, when the spores escape.

Sporangial cells, germ cells; enlarged cells containing germs which, when fecundated by the spermatozoids and liberated by

the dehiscence of the parent cell-wall, become "resting spores," and germinate into new plants.

Sporangium, in desmidiæ, a smooth or rough body formed by the rupture or dehiscence of cells and the union of the cell contents during the act of conjugation, from which are developed a new generation of similar plants. The term "sporangium," pl. "sporangia," is applied to the structure immediately enclosing the spores of the Cryptogamia.

Spore, the conjunction of two reproductive vegetable cells forms a spore, germ, or seed, or numbers of them; embryo cell or seed of Cryptogamic plants.

Sporidia, clusters of sporules. s. *Sporidium*, a spore.

Sporidiola, a term applied to nuclei or granular masses occurring in the cavities of spores, or to the separate portions of contents of imperfectly septate stylospores.

Sporocarp, the structure or capsules containing the sporanges of a family of flowerless plants, the Marsileaceæ.

Sporules, minute spores.

Squamose, scaly.

Squarrose, *Squarrous*, ragged, or rough; with the extremities very much reflexed; consisting of scurf or scales divaricating very widely. *Martyn*.

Stage, that part of a microscope just below the objective which carries the glass-slides containing the objects for examination; also called the "stage plate."

Stage Micrometer, a slip of glass divided at its center into $\frac{1}{100}$ths, $\frac{1}{500}$ths, or $\frac{1}{1000}$ths of an inch; it is placed on the stage, the same as an object to be examined, for the purpose of determining the power of an object glass, as well as the value of each space in the micrometer eye-piece. For opaque objects the stage micrometer is generally a slide of ivory divided in $\frac{1}{100}$ths or $\frac{1}{200}$ths of an inch. These micrometers can be obtained from Spencer of Canastota, N. Y.; Grunow of New Haven, Ct.; Mc Queen, McAlister & Bro., and Amsler of Phila.; B. Pike, of N. Y.; Jas. Foster, and H. Ware, Cincinnati, O., etc., varying in price from $3 to $4.

Stauros, a cross. A band of silex crossing the valves of diatoms at right angles to the median line,—a central nodule being absent.

Stellate, consisting of star-like figures.

Stemmata, rudimentary single eyes seated on the top of the head of insects.

Sterenchyma, a name which might be used to distinguish the bony cellular tissue of shells, stones of fruits, etc.

Stereoscopic, the appearance of a flat body or picture, by which it seems to stand out solid, in bold relief, like the real object from which the picture was taken.

Sterigma, a slender filament terminating in a stylospore, among some Fungi.

Sterigmata, stalk-like elongations of the outer extremity of cells; plural of "Sterigma."

Stichidium, among the Algæ a peculiar kind of lance-shaped, pod-like receptacle, in the fronds, containing tetraspores. (pl. *stichidia*.)

Stigmata, spiracles, or breathing pores; passages through which the air enters and is discharged from the tracheal system of insects.

Stipes, stems, or stalks; flexible, stalk-like appendages by which Diatoms attach themselves to stones, wood, etc.; the base of a frond; the stem of a fungus.

Stipitate, having a stem or stalk.

Stolons, peduncles, or narrow foot stalks of sarcode, by means of which a number of its segments are connected together; runners or shoots from a plant.

Stomata, breathing pores of the epidermis of certain parts of plants.

Striated, marked with fine lines or striæ.

Stromata, minute fleshy papillæ of cellular structure, the surface of which is clothed with elliptic, oblong, or fusiform stylospores, in some parasitical Fungi.

Strumose, furnished with a thickened part below the capsule.

Styles, thick straight setæ, generally on the underside of the body of an animalcule, used for supporting the body, and for climbing; they never vibrate, are not hooked or bent at their extremities, and have no bulbous base.

Stylospores, in Fungi and Lichens in which the normal fructification consists of spores contained in asci or thecæ, there are produced other *naked spores* which are borne upon pedicels, of greater or less length, and which are termed stylospores.

Sub, under, below; approaching to.

Submentum, under the chin.

Subrotund, almost round. *Lee.*

Subulate, awl-shaped.

Succubous, leaves are so called when each covers with its lower edge a little of the leaf below it, as in the Hepaticaceæ.

Suctoria, suckers.

Sulcus, pl. Sulci; depressions, grooves, furrows.

Sulcate, furrowed, grooved. *Martyn.*

Superficial measurement, the square of the linear measurement; rarely used except to astonish the public. See *Linear Measurement.*

T.

Tarsus, the foot or toe of insects, which is articulated, and formed of from one to five joints. (pl. tarsi.)

Tela Contexta, this name is used to indicate the interwoven tissue formed by the ramified, jointed filaments of the mycelium of Fungi, and the cottony substance in the interior of the thallus of many Lichens. *Mic. Dict.*

Tentacula, long, thread-like, non-articulated appendages, simple or branched, with which many animals are provided, and which serve as organs of motion or prehension, but more commonly as organs of feeling. The prehensile organs of polypes. (s. *tentaculum.*)

Terete, cylindrical and tapering. *Martyn.*

Terminal, constituting the extremity or end.

Tessellated, chequered, or marked into squares like a chess board. *Martyn.*

Test Objects, objects to test the resolving, defining and penetrating power of objectives; generally those scales or diatoms which are very minutely striated or beaded.

Tetraspores, four secondary cells, or spores enclosed within a primary cell or spore; a mass of four spores conjoined. (*See Octospores.*)

Thalamium, the entire mass of thecæ and paraphyses in Lichens.

Thallophytes, plants consisting of only a thallus or bed of vegetable matter without stem, leaf, or root.

Thallus, a lobed and foliaceous, hard and crustaceous, or leprous substance, answering as the leaf and stem of Lichens.

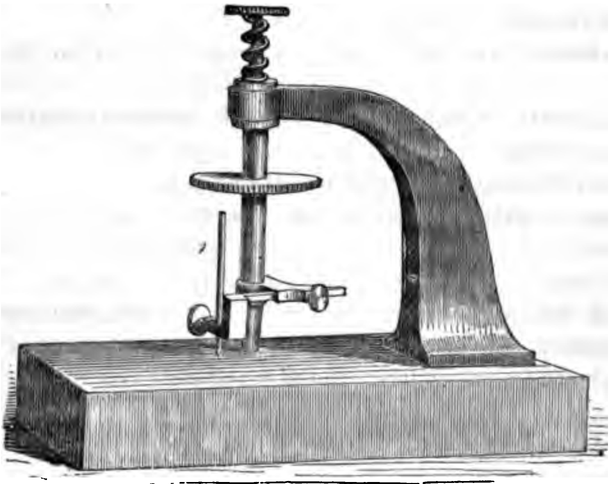
Theca, (pl. *thecæ.*) a sheath or sac; membranous tubes or sporan[illegible] ptogamic plants, analogous to an ovary, and con-

taining the spores or seeds. Seed case of ferns; capsule. See *Asci.*

Theca-sporous, Theca-spores, spores growing in the interior of sacs, (thecæ or asci.) See *Ascospores.*

Thin-glass, for covering transparent objects is made by Messrs. Chance & Co., of Birmingham, Eng., and may be obtained of their agents in this country Messrs. Heroy, Struthers & Co., No. 42 Cliff Street, N. Y., for $1 per ounce; it varies in thickness from the $\frac{1}{20}$th, to the $\frac{1}{250}$th of an inch. It is hard, brittle, and unannealed, and when cut with the *writing* diamond requires great care, as it is apt to crack, and split or "star," after having been cut, especially if any of the diamond marks are left upon it. For cutting circular covers, the Messrs. Grunow of New Haven, Conn., manufacture a cheap and very efficacious instrument. *See fig.* 107. Much care is required in cleaning the thin glass, as it is very apt to break, when roughly handled between the thumb and finger.

Fig. 107.



Tibia, the leg of an insect.

Tortile, twisted, coiled, wreathed. *Martyn.*

Torula cerevisiæ, the yeast plant, composed of cells, of which yeast is almost wholly made up, and the growth or increase of which in fluids aids their fermentation.

Thorax, the *corselet*, or middle portion of the body of insects, which is composed of three rings or segments.

Trabeculæ, movable organs situated in front of the antennæ.

Transmitted light, light sent from one body through or to another; as from the mirror of the microscope to and through the transparent object on the glass slide, by which its internal structure may be examined.

Trapezoidal, shaped like a trapezoid.

Trematodes, a family of intestinal worms comprising those which are furnished underneath the body, or at its extremity with organs resembling cupping glasses, with which they adhere to the viscera.

Trichosporanges, a term used by Thuret in application to multi-septate filaments occurring in some of the Fucoid Algæ, producing ciliated zoospores in their joints. Recently, he has stated that the proper *trichosporanges* and *oosporanges* pass into one another by numerous intermediate forms, and he desires to dismiss the terms in favor of *uni*, and *multi-locular* sporanges. *Mic. Dict.*

Triquetrous, having three sides or angles.

Tritores, triturating insects.

Trochal band, or *trochal circlet*, the ciliated circle on the trochal disc.

Trochal disc, the wheel organs of rotatoria or wheel animalcules.

Trophi, the organs employed by insects in feeding.

Truncated, terminating abruptly as if cut across.

Tubercles, a little pimple-like knob; a knob or rough point. *Martyn.*

Tubular, hollow and cylindrical, in the shape of a tube.

Tunicata, animals of the mollusk tribe with a soft, transparent, homogeneous tunic.

Turbellaria, animals between Entozoa and the leech tribe, which have cilia over the whole exterior of the body.

Turbinate, top-shaped.

Type, a general form, such as is common to the species of a genus.

U.

Umbilicated, the surface depressed, and surrounded by an elevated margin.

Umbo, pl. *Umbones*, a protuberance or boss of a shield. The nucleus or apex of each valve of a bivalve, usually located above the hinge, and never far from it.

Uncinated, hooked, set or covered with bent spines like hooks.

Uncini, curved hooked like processes, like thick short hairs, emanating from the under surface of the body, and serving as organs for prehension.

Undulated, having a waved surface.

Unilateral, existing on one side only.

Unilocular, one chamber or partition.

Urceolate, shaped like an ancient pitcher; swelling in the middle like a pitcher, and narrowed at the orifice.

Utricles, little cells, bags, or bladders. *See Cell.*

V.

Vacuoles, empty circular spaces seen in certain parts of animalcules, and which are sometimes seen to close and open; also, empty spaces or circular cavities, in the protoplasm of vegetable cells, more frequently occupied with a watery fluid.

Vaginule, a little sheath or scabbard; the calyx in Mosses and Lichens; in Mosses the embryonal cell, as it matures, tears away the walls of the flask-shaped epigone by a circular fissure, the lower part of which remaining as a kind of collar round the base of the stalk, is termed the "vaginule."

Valves, the siliceous envelop of Diatomaceous frustules or cells, usually two valves or plates applied to each other like the two valves of a bivalve shell, and being of various singular and beautiful shapes. When the line of separation, or suture of the valves is presented to the eye, a *front view*, is obtained; when either valve presents its central part to the eye, a *side view* is obtained.

Variable processes, processes protruded at pleasure from any part of the body to perform the function of locomotion, as with the *Amœba*. Also called *pseudopodia*.

Variolous, resembling small pox.

Vascular, abounding with vessels; pertaining to the vessels of animal or vegetable bodies.

Ventricose, swollen in the middle, bellied out.

Venules, little veins on Ferns.

Vermicular, looking like a worm; moving like a worm.

Verrucose, covered with wart-like tubercles.

Vertebrate, furnished with a back-bone through which the spinal marrow passes.

Verticillate, whorled, in whorls.

Vesicle, a small bladder, or cavity in organized bodies.

Vibracula, organs with which some Polyzoa are furnished, which are constantly moving slowly over the exterior of the cells or sheaths of the animals, removing any foreign bodies which might prove deleterious to them when they protrude their tentacula; these organs are long, like bristles, each of which is inserted at base in a depression or cup-like concavity.

Vibratile, when there is a constant oscillating motion of any part.

Virgate, long and straight, like a wand.

Viscous, slimy, sticky, gummy, clammy.

Visual power, that power in telescopes and microscopes, (being a compound of their magnifying and penetrating powers,) which aids vision, enabling the observer to see objects more distinctly, independent of illumination, and which is indeed the principal power in these instruments which renders them of value in the investigations for which they are designed.

Vittæ, a riband; peculiar bands or dark lines seen on the front of the frustules of Diatoms, usually sinuous. Little clavate oil vessels of plants.

Vivarium, a place for keeping live insects, animals, etc. *See Aquarium*,.

Viviparous, bringing forth the young alive, but not by eggs.

Volubile, *Volubilate*, twining, a stem that climbs by twining round another body. *Cyc.*

Volvox Globator, a common object seen in fresh water streams, consisting of from two to twenty green spots or globes enclosed in a hollow, very transparent sphere, the motion of which is generally of a revolving kind. These green globes or spots are at regular distances from each other, and throw out, each, two long vibratile filaments or cilia to whose united simultaneous action the revolutions of the sphere are owing. If the sphere enclose twenty of these green bodies, its external surface will have issuing from it, forty of these cilia at equal distances from each other. After a certain time, the hollow enclosing sphere ruptures, the green spots or sphericles float out, and soon become transformed into other volvoces or revolving bodies. They were formerly called "globe animalcules," from a supposition that they were animalcules, but they are now known to belong to the vegetable kingdom, being simple fresh water

Algæ. They may be mounted in glycerin, or Canada balsam. In the summers of 1852-53, at various times, I saw under the microscope similar bodies, containing four or nine bright, translucent, crimson-colored globes in each sphere, but have seen no account of such red volvoces in any work.

Vorticella nebulifera, a bell shaped animalcule attached to a long stalk by which it is fastened to some object; the stalk is very contractile, being closed spirally with a kind of jerk or shock. The animals have actively vibrating cilia which are in constant motion when they are in search of food. The Vorticella may be met with separately or in groups.

W.

Wheel Animalcule, Rotifer Vulgaris. From *rota* a wheel, and *fero* to carry. A genus of microscopic animals belonging to the class Rotatoria. The species live in fresh water, or among wet moss, or in the mud collected in the gutters on the roofs of houses. They are very transparent, so that all their interior organization can be seen; are of a fusiform shape, very slender, and possess the power of contracting the body into the shape of a ball. In front, the body terminates in a slender truncated proboscis, furnished with several vibratile cilia, by means of which the animals can creep like leeches. The anterior part of the body is furnished with a retractile, often lobed disk, upon which are usually placed vibratile cilia, which, when in motion, present the appearance of one or two wheels revolving swiftly in opposite directions. By means of these rotatory organs the animals swim freely about, revolving upon their axis, or, when at rest, producing vortex-like motions of the water, by which means food or prey, is carried to their mouths. They have two eyes situated upon the proboscis, and the tail is bifurcated. The tail-like process at the posterior end of the body, called the false foot or foot-like tail, has four or six appendages called toes, the whole of which, as well as the rotatory apparatus, can be drawn, at pleasure, into the body of the animal. *Baird.* These animals are sensitive to sound or slight shocks, as a light blow upon the microscopic stage when they are extended, will cause them to at once retract themselves.

(George Adams in his Micrographia Illustrata, 1771, states that if some anemony plant (leaves and flowers) be placed in

cold water, at the end of eight days an animalcule will be afforded, the surface of whose back will be covered with a very fine mask in the form of a human face, perfectly well made; it will have six feet, three on each side, a tail issuing from under the mask, and a knobbed protuberance above the top of the mask.)

Whorled, surrounding a branch in a ring or whorl.

Winter Spores, spores which may float about in the atmosphere, or be otherwise exposed for months and even years, without having their vitality destroyed; and which germinate or conjugate whenever the necessary elements act upon them simultaneously, as heat, moisture, and atmosphere.

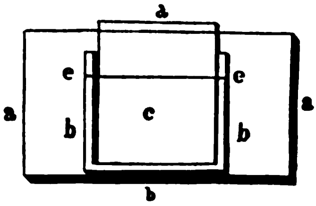
Z.

Zigzag, having short turnings and angles.

Zoophytes, Polypifera, or polype-bearing animals, having more or less of a plant-like form.

Zoophyte-trough, a quadrangular glass trough, formed by joining together upon a large glass slide, by means of marine glue, and in the manner shown in fig. 112, three slips of plate glass about an inch in length, three eighths of an inch in width, and about the same measurement in depth; over these a plate of thin glass is cemented, either by marine glue or Canada balsam. By this means a small trough is formed, adapted for the examination of living aquatic objects under the microscope. The open end of this trough is near one of the longitudinal margins of the glass slide. A loose thin piece of plate glass may be kept in the trough for the purpose of holding objects under examination against the thin glass. It is used only when the microscope is inclined in a horizontal position. (*See fig.* 112.)

Fig. 112.



a a, large glass slide or plate of glass. b, b, b, three slips of glass cemented upon the slide. c, the thin glass cemented upon the slips. d, the loose plate of glass fitting into the whole length of the trough; the entrance or opening into the cavity of the trough is at e, e.

By making a small groove across the upper surface of the

two side slips, b b, somewhat near their center, immediately under the thin glass, and exactly opposite to each other, and inserting in each a fine metallic needle, and then placing on the extremities of the slide a brass plate arranged somewhat similar to that named under *Magnetic slide*, so that the copper wires may be brought into contact at any time with the needle cemented across the glass slips, a *magnetic zoophyte-trough* may be made, by which the objects under observation may be subjected to the action of galvanism, etc. Instead of one needle to each slip, two or more may be inserted at various distances from each other, with other additions to suit the observation.

Zoospores, motile gonidia; movable spores. They originate within a mother cell, either singly or in numbers, and have one or more vibratory cilia.

Decagon, decagonal, decahedral, decahedron ; ten sides or angles.

Dihedron, dihedral, digon, digonous ; two sides or angles.

Dodecahedron, dodecahedral, dodecagon, dodecagonal ; twelve sides or angles.

Heptagonal, seven sides or angles.

Hexagonal, six sides or angles.

Icosahedron, icosahedral ; twenty sides or angles.

Nonagon, nonagonal, enneagon, enneagonal ; nine sides or angles.

Octagonal, octohedron, octahedral ; eight sides or angles.

Pentagon, pentagonal, pentahedral, pentahedron, pentahedrous ; five sides or angles.

Polygonal, polyhedron, polyhedral ; many sides or angles.

Quindecagon, fifteen sides or angles.

Quinquangular, five angles or sides.

Tetragon, tetragonal, tetrahedron, tetrahedral ; four sides or angles.

Trigonal, trihedron, trihedral ; three sides or angles.

Triquetrous, having three sides or angles.

SIGNS USED BY MICROSCOPISTS.

" means an inch,—

''' means a line; thus $\frac{1}{100}$", or .01" means one hundredth of an inch; $\frac{1}{60}$''' or .01666+''' means one sixtieth of a line, or $\frac{1}{720}$th of an inch; 2''', means two lines or $\frac{1}{6}$th of an inch, etc. Twelve lines is equal to an inch; though it is generally difficult to determine what measurement is meant to be expressed by foreign microscopists when they give it in lines, as some mean the $\frac{1}{12}$th of an inch, and others the $\frac{1}{10}$th.

↗ or +, means polarization from left to right, or right-handed polarization.

↖ or —, means polarization from right to left, or left-handed polarization.

×, means diameters; thus × 600, stands for 600 diameters.

○, means, when viewed under the polarizing apparatus, thus, "*Salicin* ○ *presents most gorgeous colors*," should be read "Salicin when viewed under the polarizing apparatus presents most gorgeous colors."

Ang. ap, Angle of aperture.

c. c. cubic centimetres.

d. l. means direct light.

E. V. end view of an object.

F. frustule.

F. V. front view of an object.

m. b. means mounted in balsam.

m. co. do. do. " castor oil.

m. d. do. do. dry.

m. f. do. do. in fluid.

m. g. do. do. in glycerine. Thus, "*this tissue m. f. Goadby's* 1 (*or A*);" means "this tissue mounted in Goadby's solution A;"—"*these cells m. f. chlor. calc.*" means "these cells mounted in a solution of chloride of lime;"—"*when m. f. Thwaite's.*" means, "when mounted in Thwaite's liquid," etc.

m m. means millimetre.

n. a. or *n. ap.*, means new aperture.

o. l. means oblique light,—" thus ***podura o. l. presents the lines more distinctly***," should be read "podura viewed by oblique light presents the lines, etc."

r. l. reflected light.

S. V. side view of a specimen.

t. l. transmitted light.

V. valve.

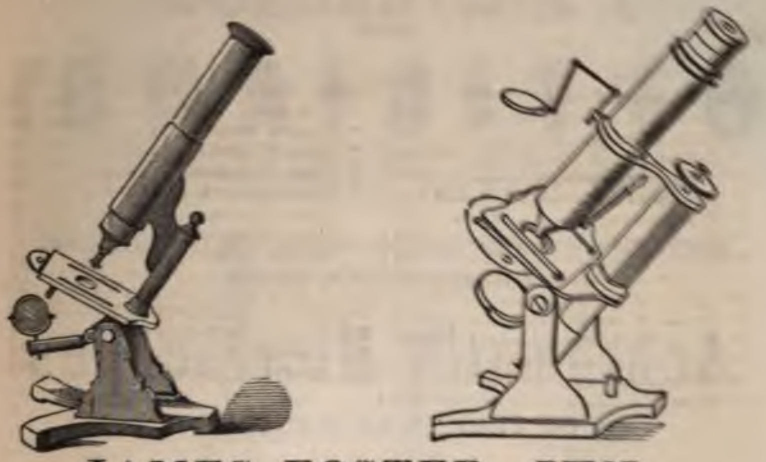
V. S. a dry or fossil specimen examined; mounted dry.

V. V. a living specimen examined.

N. B. For the principal part of the matter under ***Cements***, *Chemical Tests*, and *Preservative Fluids*, I am indebted to the London Quarterly Journal of Microscopic Science, Micrographic Dictionary, Tulk & Henfrey's Manipulation, Quekett on the Microscope, Beale on the Microscope, Schaht on the Microscope, etc.—J. K.

INDEX.

THE END.



construction, which is introduced within the body of the the Microscope, by means of an adapter, in such a way as not to disturb the *corrections* nor any optical condition of the objective, even when of the highest angle of aperture. The power of the Microscope with any given objective and eye-piece is thus DOUBLED, the *eye-distance*, at the eye-glass, remaining undiminished,—i. e. double the eye-distance possible by means of the draw-tube, (or higher eye-piece) when affording equal amplification. The optical result is *theoretically* and *actually*, beyond comparison, better than that obtained by means of the draw-tube,—using the same *objective* and *eye-piece*. But the chief and otherwise *unattained* advantage in the use of the amplifier is, *perfect* flatness of field. Even with the lowest objectives, 1 in. or 2 in., a section of wood, (in perfect plane, parallel to the field), will be in *well defined* view *throughout* the field at one adjustment for focus. This result is obtained in conjunction with a good objective, and any eye-piece of the common construction, thus avoiding the expense of Orthoscopic Eye-pieces, which give only a fair *approach* to flatness of field, involving at the same time *increased* secondary color; whereas the Amplifier certainly *reduces* the secondary spectra of the object-glass. The Amplifier, with the Adapter is furnished for $10.00.

Orthoscopical Eye-pieces, as good as any in market,—and upon the formula and construction of which much attention has been expended, are furnished, A and B, for $10. C, and higher powers, each, $8.

The Solid Eye-pieces are furnished with a micrometer, engraved in the solid substance thereof, in the focus of the *eye-surface*, at an additional charge of $2.

R. B. TOLLES is now prepared to supply—and with promptness —*Microscope Mountings of unexceptionable workmanship*, and of any pattern. In this department he has secured the coöperation of Mr. C. E. Grunow, formerly of New Haven, Conn., who will give his personal and entire attention thereto, so that the advertiser feels confidence in undertaking to satisfy the most exacting in the way of a good microscope mounting. His prices shall correspond with the lowest rates for the best work in market; and whatever orders are given to him in this department, will be supplied under his careful inspection and warranty.

The *adjustment* for thin glass cover, and the fine adjustment for focus, in his instruments, are new—a[illegible] *ly*,—and by no possibility can ever acquire " [illegible] *oint.*" The fine adjustment for focus is p[illegible] the objective,—a convenience obvious [illegible] se adjustments have not been supplie[illegible]

TELESCOPES of *unusually* large [illegible] ac-tured under special contract.

No. 105.

No. 113.

CREDENTIALS.

THE sheets of the MICROSCOPIST'S COMPANION were placed in the hands of a few persons of this city while the work was at the binder's, and the following communications have been received:—

From Prof. I. J. Allen, A. M., M. D., Superintendent of Public Instruction.

Cincinnati, May 4th, 1859.

WHILE the Telescope unfolds to man the wonders of a universe of worlds, the MICROSCOPE reveals the wonders of a universe of atoms. The former, folding back the curtains of the skies, bids him behold Creation's vastness; the latter, lifting the veil of invisibility, invites him to witness Creation's minuteness; and, by the mutual aids, in both the vast and the minute, he sees " the unambiguous footsteps of a God."

To this latter co-adjutor of the human eye, Science, too, has appealed, of late, for the demonstration of some of her sublimest theories and profoundest truths. By the Microscopic Lens, the mysteries of creative development in organic structures have been invaded, and the functions of monad, spore, and cell disclosed. And in the presence of these revelations the curious have wondered, the wise admired, and the devout adored. Any step, therefore, that shall serve to bring this instrument, of such universal interest, into universal use, must prove a benefit to man, and a boon to science. An important contribution to this end is "THE MICROSCOPIST'S COMPANION," by Prof. J. King.

The author has treated clearly and compactly, of the structure of the Microscope in all its varieties—of the peculiarities of and special qualities of each—the methods of its use in every department of physical science, including all the requisite accessories and preparations, so that even the tyro can manipulate therewith as successfully as the philosopher. Its Glossary of technology is elaborate and complete; the engravings are numerous and fine, and the typography beautiful: a book, in every way, worth its price.

I. J. ALLEN,
Superintendent of Public Instruction

From A. J. Rickoff, Esq. Formerly Superintendent of the Schools of Cincinnati.

Cincinnati, April 26th. 1859.

Prof. John King:

Dear Sir:—After having examined the sheets of the "Microscopist's Companion" with some care, I submitted them to the inspection of Mr. Wm. M. Davis, who is well known as one of the ablest scientific and practical Opticians, and I am now prepared to congratulate you most heartily upon the publication of a book, which, I believe has no rival, certainly not in the United States. It is accurate so far as I have had the pleasure of examining it, in every department of which it treats; yet its style is interesting and popular. The Microscope, notwithstanding its wonderful revelations, and the ease and pleasure with which it can be used by the amateur, is comparatively little known even to many scientific men. Your work will have a tendency to bring this valuable instrument into common use. It contains much information, which, without its aid, could be obtained only by the combination of many expensive books not easily accessible to the student, and ought to be in the hands of every general reader, every teacher, and every professional man. Yours truly and respectfully,

ANDREW J. RICKOFF.

From Wm. M. Davis, Esq.

Cincinnati, April 26th, 1859.

I heartily concur in the recommendation of the "Microscopist's Companion."

WM. M. DAVIS.

From Peter Neff, Jr., Esq.

Cincinnati, Ohio, April 27th, 1859.

Dr. Cleaveland:

Dear Sir:—I have examined the sheets of Dr. King's compilation on the microscope. I think the work will inspire a love for this interesting branch of knowledge, but I don't feel that my endorsement will be of any advantage to its sale, seeing I am only a low private in the science. Hoping you may have great success, and realize your wishes in this enterprise, I remain yours with respect.

PETER NEFF, JR.

EOSCOPES AND VIEWS, SPECTACLES, &c.

From Rev. D. Shepardson, D. D., Principal of the Woodward High School.

WOODWARD HIGH SCHOOL,
Cincinnati O., April 25th, 1859.

PROF. KING:

Dear Sir:—The deep interest I have long felt in scientific investigations by the Microscope, causes me to rejoice in your forth-coming work. No one can over-estimate this wonderful instrument, as a revealer of God and truth, in nature; and any book that tends to make its sublime and useful disclosures more generally known in all our schools and families, must prove a rich blessing. An examination of your work convinces me that it is well adapted to secure this result. Yours, etc.

D. SHEPARDSON.

From Prof. Knowlton, Principal of Hughes High School.

HUGHES HIGH SCHOOL,
Cincinnati O., April 23rd, 1859.

JOHN KING, M. D.

Dear Sir:—Accept my thanks for favoring me with a view of the advance sheets of your "Microscopist's Companion." I have examined them with considerable care, much interest, and a great deal of satisfaction. Your work will fill a gap in our present means of instruction, and open to the student a comparatively new field of exhaustless variety and value. Other works in this department have been too much taken up with the *results* of microscopic examinations, affording little aid to the beginner. I am glad to see that your work gives to all who desire to study this branch of knowledge, invaluable practical assistance in all the necessary details.

We have long needed some work that would give us full instruction in the theory, structure, and manner of using the various instruments required; in the modes of collecting, preserving, preparing, and mounting the various subjects for examination; in the manner of conducting chemical investigations and applying tests; and in the means of extending medical and botanical researches. Your work supplies this want admirably. It embraces almost every science to which the microscope can be applied with success, and is so full and perspicuous in its directions, diagrams, and illustrations, that persons of moderate optical knowledge can use it with great advantage; and requires instruments so moderate in value, as to be within the reach of the most humble. It gives me much pleasure to see so useful a work issuing from our home press.

Yours very truly, CYRUS KNOWLTON.

From James W. Ward, Esq.

Cincinnati, April 29th, 1859.

DR. J. KING:

Dear Sir:—I have with much gratification looked over the proof sheets of your "Microscopist's Companion," and am happy to express to you my high appreciation of the plan of the work and the successful manner of its execution. I believe it will serve the student an excellent purpose, and prove to him precisely what you contemplated in its preparation:—a ready manual and guide for the purchase, management, and general scientific use of the Microscope; and that he will find in it an amount of instruction and information concerning practical Microscopy, that without its aid, he could only obtain from more voluminous and expensive works, which he would find a difficulty in procuring. I confidently recommend your treatise to students, and believe that it will admirably fulfil the purpose for which you designed it, and prove a cheap and compendious handiwork of microscopical manipulation. Sincerely Yours,

JAS. W. WARD.

TEREOSCOPES AND VIEWS, SPECTACLES, &c.